Research Article

Optimizing Nitrogen Fertilization Regimes for Sustainable Maize (*Zea mays* L.) Production on the Volcanic Soils of Buea Cameroon

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Nitrogen (N) fertilizer is commonly used to improve soil fertility and maize production in Cameroon, but high cost and potential environmental effects have necessitated site-specific N fertilization regimes that are adapted to particular soil and crop types. A field experiment was conducted with five N application rates (control–0, 50, 100, 150, and 200 kg N ha⁻¹) to determine optimum rate for best maize yield with limited effect on soil acidification. The soil residual N ranged from 0.18 to 0.36% across N application rates and increased at higher application rates with the highest in 150 and 200 kg N ha⁻¹. Soil C/N ratio ranged from 7.5 to 15.5 across N rates with the highest in control, which decreased at higher N application rates. Soil pH ranged from 4.7 to 5.4 across N rates, with the lowest in 200 kg N ha⁻¹ rate. Maize grain yield and cob length ranged from 7.1 to 10.3 t ha⁻¹ and from 14.5 to 18 cm across N rates, respectively, with the highest in 150 and 200 kg N ha⁻¹. Maize 1000-grain weight ranged from 380 to 560 g across N application rates with the highest in 100, 150, and 200 kg N ha⁻¹. Significant negative correlations occurred between soil pH and maize yield or 1000-grain weight. Maize N use efficiency decreased sharply at higher N application rates, as demonstrated by a strong negative correlation between the N-Partial Factor Productivity and total soil N. Overall, the lower soil pH at higher N application rates highlights the potential for deleterious effects of N fertilizer inputs on arable soils, which may eventually affect crop productivity, thereby suggesting lower N fertilization regimes between 50 and 100 kg N ha⁻¹ as the optimum for maize production on the volcanic soils of Buea.

1. Introduction

Maize (*Zea mays* L.) is an important food crop in sub-Saharan Africa (SSA) that contributes significantly to food security and income generation for many smallholder farmers [1]. However, maize production is constrained by various biotic and abiotic factors including inadequate mineral nutrition [2, 3]. Poor and declining soil fertility is a major challenge for crop production in SSA, with nitrogen (N) and phosphorus (P) as the most limiting elements [4, 5]. Nitrogen mediates uptake and utilization of other nutrients and contributes to maize growth and yield [6]. Nitrogen fertilizers are commonly used to improve soil fertility and plant nutrition,

but nitrogen inputs can only increase maize yield up to a maximum rate for any particular site based on soil and climatic conditions [7–9]. Moreover, crops often take up less than half the amount of N applied, while the rest is lost as gaseous nitrous oxide emissions and nitrate leaching or added to soil organic matter, which reduces N use efficiency in agricultural systems [10–13]. Because of the low N recovery rate by crops, large amount of unused N is released into the environment leading to adverse impacts [14, 15]. Likewise, excessive N application causes soil degradation, nutrient imbalance, salinization, and acidification as soil pH decreases [16–18]. Hence, the enduring use of N fertilizer can cause deleterious effects on soil that may reduce its ability to

function as a vital system to sustain productivity within the limits of an ecosystem [19–21].

SSA accounts for only 0.1% of global mineral fertilizer production and less than 10 kg ha⁻¹ fertilizer use compared to 87 kg ha⁻¹ for developed nations, which partly accounts for low crop productivity with over 30% yield gap between actual production and attainable potential [22–24]. The use of fertilizer is being encouraged in SSA, as increase in fertilizer nutrient input, especially N fertilizer, has contributed significantly to the improvement of crop yields in the world [25]. To maximize grain yield, farmers often apply a higher amount of N fertilizer than the minimum required for maximum crop growth [26]. However, excess nitrogen input might affect soils and jeopardize sustainable development that can only be achieved when arable systems are resource conserving, socioculturally supportive, commercially competitive, and environmentally friendly. Also, crop response to different N fertilization rates may vary across soil types and locations or ecological zones [27–30]. Therefore, it is important to optimize nitrogen fertilization in relation to specific soil and crop needs for optimum productivity [3, 9, 31]. Some studies have focused on the agronomic benefits of N fertilizers for maize [3] without considering potential effects of higher N fertilization rates on soils, which may in turn affect crop productivity. Hence, this field study was intended to determine the optimum nitrogen fertilization rates for maize production with limited effects on the volcanic soils of Buea, Cameroon. We hypothesized that maize yield will increase at high N rates with 100 kg ha⁻¹ N as the optimum for maize production without significant effect on soil acidification.

2. Materials and Methods

2.1. Field Site. This field experiment was conducted from February to August 2018 at the teaching and research farm of the Faculty of Agriculture and Veterinary Medicine, University of Buea, located between latitudes 4°3'N and 4°12'N and longitudes 9°12'E and 9°20'E. The soil is derived from weathered volcanic rocks dominated by silt, clay, and sand [32]. Buea has monomodal rainfall regime with less pronounced dry season and 86% relative humidity. Dry season starts from November to March, with 2800 mm mean annual rainfall and 19–30°C monthly air temperature. Soil temperature at 10 cm depth decreases from 25 to 15°C with increasing elevation from 200 to 2200 m, respectively, above sea level [32, 33].

2.2. Experimental Setup. A randomized complete block design was established comprising five treatments and four replications, giving a total of 20 experimental plots measuring 4x4 m (16 m²) each. Plots within replicates were separated by 1 m alley and 1.5 m separated replicates from each other, while 2 m buffer surrounded the entire experimental site. The site was manually cleared using a cutlass and tilled at about 30 cm depth using a hoe. Fertilization rates include control–0, 50, 100, 150, and 200 kg N ha⁻¹ urea-nitrogen applied as two split doses at two and six weeks after sowing. Two weeks after sowing, all plots were amended with 150 kg ha⁻¹ phosphorus

(single superphosphate) and 50 kg ha⁻¹ potassium (muriate of potash–KCl) to achieve macronutrient (NPK) balance. All fertilizers were applied by ringing at about 5 cm from plants to avoid burns and minimize nutrient loss through leaching and volatilization.

2.3. Crop Management. Maize seeds (Cameroon maize selection, CMS 8704) were purchased from an agro-shop in Buea and manually planted at about 3–5 cm soil depth at 75x50 cm inter- and intra-row spacing, respectively. Three seeds were planted per stand and later thinned to two vigorous plants per stand after germination, giving a total of 53,333 plants per hectare. For crop protection during the experimental period, a pyrethroid insecticide Cigogne 360 (SCPA SIVEX International® France; comprising 360 g/l cypermethrin active ingredient) was applied six weeks after planting. 20 ml Cigogne was dissolved in 15 L water and sprayed using a knapsack sprayer, and the procedure repeated every two weeks. The field site was regularly monitored for weed emergence and weeded thrice during the experimental period. Soil moisture during the entire experimental period depended on the local rainfall regime of the study site.

2.4. Data Collection

2.4.1. Soil Parameters. Preplanting soil sampling was done after clearing the field site, and seven subsamples were randomly collected at 0–15 cm depth using 3.5 cm diameter auger and bulked to form a composite soil sample (25th April 2018). At tasseling eight weeks after sowing (5th July 2018), seven soil subsamples were randomly collected from each plot at about 5 cm from maize plants at 0–15 cm depth and bulked to form a composite soil sample for assessment of soil physicochemical properties. The soil samples were air-dried and sieved through 2 mm mesh. Soil particle size distribution was determined using the pipette method with sodium hexametaphosphate as dispersing agent [34]. Soil pH was determined potentiometrically in water (H₂O) solution after 24 hours in soil suspension (soil/liquid = 1/2.5 w/v). Exchangeable bases were extracted with neutral ammonium acetate solution. Calcium (Ca) and magnesium (Mg) were determined by atomic absorption spectrophotometry while potassium (K) and sodium (Na) were determined by flame photometry [35]. Exchangeable acidity was determined by KCl extraction method [35]. Soil available phosphorus (P) was determined by Bray II method [35] and soil organic carbon determined by Walkley-Black method [36]. Total nitrogen (N) was determined by the Kjeldahl digestion method [37]. Soil residual nitrogen (RN) was calculated as = *Actual nitrogen* – *Baseline nitrogen*, and maize N use efficiency (kg kg⁻¹) was assessed [38] by calculating the N-Partial Factor Productivity (N-PFP) = *grain yield of fertilized plants/amount of N fertilizer applied*.

2.4.2. Maize Growth and Yield. Data on maize growth and yields were collected from eight randomly selected and tagged plants on each plot. Stem girth was measured at 2/3 of the plant height using a vernier calliper and expressed in cm. The leaf area index (LAI) was sampled for the 2nd leaf

below the main ear, at eight weeks after sowing. Leaf length and width of sampled plants were measured using a meter rule, and the LAI was calculated using the following formula: $LAI = L \times W \times K$, where L is length of leaf, W is width of leaf, and K is constant-0.75 [39]. Maize plants from each replicate were manually harvested at maturity (16th August 2018), hand-threshed, and oven-dried at 60°C for three days. Dry maize grains were weighed on a scale balance to obtain the total yield ($t\ ha^{-1}$), while randomly selected 1000-maize grain weight (g) was recorded per treatment.

2.5. Statistical Analysis. Data sets were subjected to statistical analyses using Statistica 9.1 for Windows [40]. Dependent variables (soil and plant parameters) were subjected to univariate analysis of variance (ANOVA, $P < 0.05$) to test effects of nitrogen fertilizer rates ($n=5$) as categorical predictors. Significant data means were compared by post hoc Tukey's HSD test ($P < 0.05$). In addition, Spearman's Rank Correlation ($P < 0.05$) was performed to determine the degree of association between maize performance as dependent variable and soil parameters as the categorical predictors.

3. Results

3.1. Effect of Nitrogen Fertilizer Rates on Soil Properties. The preplanting baseline soil at the experimental site (Table 1(a)) was dominated by clay (47.19%), silt (44.44%), and sand (8.37%), with an acidic pH (5.42). Postplanting soil conditions were affected by the different N rates after eight weeks of sowing. Total soil nitrogen ranged from 0.18 to 0.36% that differed significantly (ANOVA: $F_{4,19} = 103.4$, $P < 0.001$; Figure 1) across N rates. The highest soil nitrogen occurred in 150 and 200 $kg\ ha^{-1}$ N rates that differed from the control, 50 and 100 $kg\ ha^{-1}$ N rates ($P < 0.05$). The lowest soil total nitrogen occurred in control that differed from all the other N application rates ($P < 0.05$). Overall, the total soil nitrogen increased at higher N rates up to 150 $kg\ ha^{-1}$ that did not differ significantly from 200 $kg\ ha^{-1}$ N rate. Compared to the baseline total soil nitrogen, residual soil nitrogen increased from 0.01% in control to 0.19% in 200 $kg\ ha^{-1}$ N rate (Tables 1(a) and 1(b)). Soil C-N ratio ranged from 7.5 to 15.5 across N rates that differed significantly (ANOVA: $F_{4,19} = 11.88$, $P < 0.001$; Table 1(b)). The highest C-N ratio occurred in the control plots that differed from 100, 150, and 200 $kg\ ha^{-1}$ N rates ($P < 0.05$). The soil C-N ratio for 200 $kg\ ha^{-1}$ N rate also differed from 50 $kg\ ha^{-1}$ N rate ($P < 0.05$). Soil pH (H_2O) ranged from 4.66 to 5.40 across N rates and differed significantly (ANOVA: $F_{4,19} = 4.1$, $P < 0.05$; Table 1(b)). The highest pH (H_2O) occurred in control and 50 $kg\ ha^{-1}$ N rate, which differed from 200 $kg\ ha^{-1}$ N rate that demonstrated low pH values representing increasing soil acidification at higher N rates ($P < 0.05$). Significant ($P < 0.05$) negative correlations occurred between soil pH and maize yield ($r = -0.78$) or 1000-grain weight ($r = -0.59$). The soil sodium content ranged from 0.17 to 0.31 $cmol\ kg^{-1}$ across N rates and differed significantly (ANOVA: $F_{4,19} = 4.7$, $P < 0.05$; Table 1(b)) with the highest in 150 $kg\ ha^{-1}$ N rate that differed from control, 50 kg and 100 $kg\ ha^{-1}$ N rates ($P < 0.05$).

FIGURE 1: Effect of nitrogen fertilizer rates (control-0, 50, 100, 150, and 200 $kg\ ha^{-1}$) on total soil nitrogen (Mean $\pm$ SD). Values across N fertilizer rates with different letters are significantly different ($P < 0.05$).

3.2. Impact of Nitrogen Fertilizer Rates on Maize Performance.

Maize cob length ranged from 14.5 to 18 cm across N rates that differed significantly (ANOVA: $F_{4,19} = 23.5$, $P < 0.001$; Table 2), with the highest in 150 and 200 $kg\ ha^{-1}$ N rates as compared to control. However, maize vegetative parameters such as plant height, stem girth, number of leaves, and leaf area index did not differ across N rates ($P > 0.05$; Table 2). Maize grain yield increased with increasing nitrogen rates and ranged from 7.1 to 10.3 $t\ ha^{-1}$ across N rates that differed significantly (ANOVA: $F_{4,19} = 31.2$, $P < 0.001$; Figure 2). The highest grain yield occurred in 150 and 200 $kg\ ha^{-1}$ N rates that differed from control and 50 $kg\ ha^{-1}$ N rate ($P < 0.05$). 200 $kg\ ha^{-1}$ N rate also differed from 100 $kg\ ha^{-1}$ N rate, while 100 $kg\ ha^{-1}$ N rate differed from control ($P < 0.05$). Similarly, the maize 1000-grain weight increased at higher N rates and ranged from 380 to 560 g across N rates that differed significantly (ANOVA: $F_{4,19} = 23.5$, $P < 0.001$; Figure 3). The highest maize 1000-grain weight occurred in 100, 150, and 200 $kg\ ha^{-1}$ N rates that differed from control and 50 $kg\ ha^{-1}$ N rate ($P < 0.05$). Maize nitrogen use efficiency decreased at higher N fertilizer application rates as demonstrated by Nitrogen-Partial Factor Productivity (N-PFP) of 51.3–165.7 $kg\ kg^{-1}$ that differed (ANOVA: $F_{3,15} = 275.07$, $P < 0.001$; Figure 4) significantly across N rates and correlated ($r = -0.94$) negatively with the total soil N.

4. Discussion

4.1. Effect of Nitrogen Fertilizer Rates on Soil Properties.

According to the guidelines for tropical soils elaborated by Landon [41], high, medium, and low soil contents correspond to >10 , 4–10 and $<4\%$ for organic carbon; >0.5 , 0.2–0.5 and $<0.2\%$ for total nitrogen; 10–15, 5–10, and 0–5 $cmol\ kg^{-1}$ for phosphorus; and >0.4 –0.8, 0.2–0.4, and <0.03 –0.2 $cmol\ kg^{-1}$ for potassium. Therefore, organic carbon and total nitrogen contents were low in this study site, while phosphorus and potassium were high [41]. The decrease in soil pH at higher N application rates is consistent with other reports and corresponds to standard tropical acid soil pH

TABLE 1: (a) Baseline preplanting soil properties of the experimental site before fertilizer application. (b) Effect of nitrogen fertilizer rates (control-0, 50, 100, 150, and 200 kg ha⁻¹) on postplanting soil properties (Mean $\pm$ SD).

(a)												
Baseline soil	Moisture content [%]	Organic carbon [%]	Carbon / Nitrogen	Available phosphorus [mg kg ⁻¹]	pH [H ₂ O]	Sodium [cmol kg ⁻¹]	Potassium [cmol kg ⁻¹]	Magnesium [cmol kg ⁻¹]	Calcium [cmol kg ⁻¹]	Acidity [cmol kg ⁻¹]	ECEC [cmol kg ⁻¹]	Total nitrogen [%]
	11.3	2.16	13	29	5.42	0.35	0.47	4.23	18.08	0.41	23.54	0.17
(b)												
Nitrogen fertilizer rates [kg ha ⁻¹]	Moisture content [%]	Organic carbon [%]	Carbon / Nitrogen	Available phosphorus [mg kg ⁻¹]	pH [H ₂ O]	Sodium [cmol kg ⁻¹]	Potassium [cmol kg ⁻¹]	Magnesium [cmol kg ⁻¹]	Calcium [cmol kg ⁻¹]	Acidity [cmol kg ⁻¹]	ECEC [cmol kg ⁻¹]	Residual nitrogen [%]
Control-0	11.5 ± 1.9a	2.8 ± 0.3a	15.5 ± 3.1a	19.7 ± 4.2a	5.4 ± 0.4a	0.18 ± 0.06b	1.5 ± 0.5a	3.4 ± 0.8a	15.4 ± 3.5a	0.09 ± 0.05a	20.5 ± 3.9a	0.01 ± 0.02e
50	11.2 ± 2.1a	2.9 ± 0.3a	12.0 ± 0.8ab	21.3 ± 4.0a	5.4 ± 0.3a	0.17 ± 0.06b	1.4 ± 0.3a	3.6 ± 1.0a	17.4 ± 3.9a	0.08 ± 0.03a	22.6 ± 5.1a	0.08 ± 0.01d
100	15.1 ± 0.4a	2.6 ± 0.2a	9.3 ± 1.0bc	20.8 ± 2.9a	5.3 ± 0.3ab	0.18 ± 0.07b	1.2 ± 0.4a	3.6 ± 0.9a	16.3 ± 3.4a	0.08 ± 0.02a	21.4 ± 4.2a	0.12 ± 0.01c
150	15.4 ± 1.0a	3.0 ± 0.7a	9.0 ± 2.4bc	26.0 ± 5.5a	5.0 ± 0.4ab	0.31 ± 0.03a	1.3 ± 0.5a	3.3 ± 0.8a	14.9 ± 2.9a	0.08 ± 0.02a	19.8 ± 3.9a	0.16 ± 0.01b
200	15.2 ± 1.2a	2.6 ± 0.1a	7.3 ± 0.5c	24.3 ± 1.5a	4.7 ± 0.1b	0.22 ± 0.05ab	1.3 ± 0.1a	4.1 ± 0.4a	18.7 ± 2.1a	0.12 ± 0.07a	24.5 ± 2.6a	0.19 ± 0.01a

Values within columns with different letters are significantly different (*P* < 0.05).

Values within columns with different letters are significantly different ($P < 0.05$).

TABLE 2: Impact of nitrogen fertilizer rates (control–0, 50, 100, 150, and 200 kg ha⁻¹) on maize vegetative and yield parameters (Mean ± SD).

Nitrogen fertilizer rates [kg ha ⁻¹]	Number of leaves per plant	Plant height [cm]	Stem girth [cm]	Leaf area index	Number of cobs per plant	Length of cobs [cm]	Circumference of cobs [cm]	Number of grains per cob
Control–0	18.9±0.5a	246±6a	9.3±0.3a	905±121a	1.0±0.0a	14.5±1.2b	14.8±0.5a	372±34a
50	18.8±0.4a	243±25a	9.3±0.2a	998±47a	1.1±0.1a	16.6±0.9ab	15.1±0.6a	422±19a
100	19.1±0.5a	248±23a	9.2±0.4a	1211±486a	1.0±0.1a	16.2±0.9ab	15.2±1.2a	437±37a
150	19.2±0.3a	240±35a	9.2±0.4a	909±59a	1.0±0.1a	18.0±1.2a	15.0±0.7a	449±41a
200	19.1±0.3a	259±16a	9.8±0.5a	1000±86a	1.1±0.2a	17.3±1.0a	15.2±0.9a	456±70a

Values within columns with different letters are significantly different ($P < 0.05$).

FIGURE 2: Impact of nitrogen fertilizer rates (control–0, 50, 100, 150, and 200 kg ha⁻¹) on maize grain yield (Mean ± SD). Values across N fertilizer rates with different letters are significantly different ($P < 0.05$).

FIGURE 3: Impact of nitrogen fertilizer rates (control–0, 50, 100, 150, and 200 kg ha⁻¹) on maize 1000-grain weight (Mean ± SD). Values across N fertilizer rates with different letters are significantly different ($P < 0.05$).

range ([18]; Li et al., 2016). These demonstrate the potential for increased soil acidification that may jeopardize soil health and productivity [15, 21]. The increased soil acidification is likely because ammonium is oxidized into nitrate by soil bacteria, which releases hydrogen ions (H^+) into the soil, and the excess accumulation of H^+ ion in soil may cause soil acidification that might affect soil nutrient availability and crop productivity [17, 20, 42]. Meanwhile, soil pH for all treatments was less than 5.5, and the breakdown of organic matter is reduced at $pH < 5.5$, which results in nutrient loss from organic matter with negative effects that may require

FIGURE 4: Maize nitrogen use efficiency (kg kg⁻¹ ± SD) assessed by the Nitrogen-Partial Factor Productivity (N-PFP) across nitrogen fertilizer rates (50, 100, 150, and 200 kg ha⁻¹). Values across N fertilizer rates with different letters are significantly different ($P < 0.05$).

liming to increase soil pH for subsequent cultivation seasons. Poor fertility of acid soils could be due to a combination of mineral (i.e., aluminium, manganese, and iron) toxicity and deficiency caused by leaching or decreased availability of phosphorus, calcium, magnesium, and other micronutrients such as molybdenum, zinc, and boron [43]. Therefore, in degraded soils without organic inputs, using higher amounts of mineral fertilizers may only poorly improve or even worsen soil quality by hastening loss of soil carbon as demonstrated by the decreasing C-N ratio in this study. Overall, the decrease in soil pH at higher nitrogen fertilizer rates is consistent with the hypothesis of this study, which could reduce nutrient availability and increase toxicity to plants [15, 16, 21].

The observed effects of higher nitrogen fertilizer application rates on soil pH and C-N ratio imply that simply promoting mineral fertilizers without integrating adapted soil management practices could be unsustainable and risky. The decreasing soil pH may not affect crop yield in the short-term as demonstrated by the results of this study, but this could have detrimental effects on soil properties in the long-term, which may eventually affect crop growth and productivity. Hence, in order to ensure sustainability of nitrogen fertilization, it is important to consider the

potential long-term effects of higher fertilizer amounts on soil properties that may in turn affect crop performance [19]. The increase in total soil nitrogen at higher N application rates is commensurate with the additional nitrogen input from the applied inorganic N fertilizer and consistent with other reports [44–46]. Meanwhile, Adekiya et al. [47] reported more than double the amount of soil N from 0.12% in the control to 0.27% in plots amended with 120 kg ha⁻¹ urea. Likely, enhanced microbial activity due to urea application increased the production and mineralization of organic matter from natural (native) source in soil, which increased the N content at higher fertilization rates [47]. The relatively low nitrogen use efficiency by maize plants at higher N application rates is consistent with other studies [48, 49] and could be partly due to the low soil pH. This highlights the potential long-term detrimental effects of unsustainable agricultural intensification involving higher nitrogen fertilization to achieve more yields, which may jeopardize the sustainability of arable systems. Therefore, as more fertilizer use is envisaged to boost crop productivity within the nexus of integrated soil fertility management, further *in situ* studies are necessary across different cropping seasons and ecological zones in Cameroon, so as to provide greater insight into potential site-specific nitrogen fertilization regimes.

4.2. Impact of Nitrogen Fertilizer Rates on Maize Performance.

The importance of nitrogen fertilization was demonstrated in this study as maize yield increased with a corresponding increase in soil nitrogen at higher nitrogen fertilizer rates [50]. However, beyond the optimum nitrogen fertilizer application rate, additional nitrogen input demonstrated adverse effects on soils with potential to negatively affect crop productivity in the long-term. The increase in soil nitrogen likely enhanced soil nutrient balance, which probably increased the availability and uptake of other essential nutrients that improved maize yield [6]. Generally, the increased maize yield with increasing nitrogen input supports the hypothesis of this study that higher nitrogen fertilizer rates will enhance maize yield. The observed significant yield difference with increased soil nitrogen could be the consequence of soil nutrient dynamics initiated by optimal soil nitrogen-phosphorus balance and essential plant metabolic pathways. This result is consistent with other studies that reported increased maize grains per cob and higher grain yield with increasing nitrogen fertilizer rates [3, 31, 51]. Overall, the significant increase in maize yield at higher fertilizer rates up to a maximum of 100 kg ha⁻¹ is consistent with reports that additional nitrogen beyond the optimum nitrogen fertilization rate had no increasing effect on maize performance [9, 28, 29]. Nonetheless, the high maize yield observed for 150 and 200 kg ha⁻¹ nitrogen fertilizer rates is consistent with other results that reported increased maize yield up to an optimum nitrogen fertilizer rate of 200 kg ha⁻¹ [27, 30]. However, these studies were more focused on agronomic benefits through maize yield potentials, without considering potential long-term effects of higher nitrogen rates on soil properties such as soil pH, which may in turn affect crop productivity. Therefore, by considering the potential effects

of higher nitrogen fertilization rates on soil properties in relation to crop yield, we demonstrated that nitrogen fertilization rate of up to 100 kg ha⁻¹ is the optimum for maize production with limited effects on the volcanic soil of Buea, Cameroon. These results are consistent with the hypothesis of this study and highlight the need for more detailed field studies to provide greater insights into potential site-specific nitrogen fertilization regimes for different crops. Besides the insignificant effect of additional nitrogen on maize biomass and yield production, the significant decrease in nitrogen recovery by maize plants at higher N application rates is in line with other reports [48, 49].

5. Conclusion

The corresponding decrease in soil pH with increasing maize yield at higher N application rates is a potential unintended recipe for soil acidification, which might cause deleterious effects on arable soil and crop productivity, thereby suggesting lower N application rates between 50 and 100 kg ha⁻¹ as optimum for sustainable maize production on the volcanic soils of Buea, Cameroon. Nonetheless, the increased maize yield with N fertilizer amendment emphasizes the importance of nitrogen inputs for maize production on the volcanic soils of Buea. Hence, while N fertilizer input is important to ensure greater crop productivity, it is necessary to consider sustainable site-specific nitrogen fertilization regimes with limited negative consequences on arable soils, so as to foster sustainable development.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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