***Detailed Responses:***

**Thank you very much for your careful reading and for your many detailed and useful suggestions. We have carefully revised the manuscript in the light of the comments made. We believe that the quality of the revised manuscript has been significantly improved and hope that our response and the revised manuscript are satisfactory.**

General comments

This manuscript addresses the combined effect of basalt powder, lime and polyacrylamide as soil amendments on soil acidification. Based on lab experiments covering soil pH buffer curves, acid damage capacities and leaching and adsorption experiments, the authors show that those amendments improve soil acidity issues by raising soil pH and reducing nutrient leaching. This topic is relevant for establishing best practices for soil management and preserving soil health. However, the manuscript contains many flaws and weaknesses in the methodology and in the interpretation of the data. While the authors are using well-established wet-chemistry methods, the description of the experimental design is not clear. The main issue is the lack of any statistical analysis of the data. The observed trends are not statistically back-upped thus there is not much confidence in the conclusions drawn from the data. Another main problem is the lack of theory-driven research questions and testable hypothesis. As such, the manuscript does not have a clear storyline and the discussion is not tied back to hypothesis. Since no hypothesis are formulated, it is difficult to decide, which results and display items are important to focus on for delivering the key message of the manuscript. Thus, the discussion lacks direction and contains many speculative and over-simplified parts, which are not supported by the results. Another issue is that there is not much information where the soil samples were taken from and how representative they are. Even the sample size is nowhere mentioned in the manuscript. If I understood it right, only one soil sample was taken and then splitted to seven aliquots without any replicates. This may explain the absence of any statistical analysis with such a small sample size. Moreover, it is a purely lab-based study with no connection to a specific study area. Thus, in how far the results and conclusion can be upscaled or applied to other soil systems remains unclear. Lastly, the wording needs to be improved. Some parts of the manuscript sound like an AI-generated text. I regret to say that the quality of the manuscript is not suitable for publication in SOIL and suggest rejection. Please see my comments below for more details.

Below are the edits and comments on the manuscript

**Response/action:** Thanks very much for your suggestions. In response to the deficiencies you pointed out in the methodology and interpretation of the data, we have made changes and additions in the new manuscript that correspond to your specific suggestions. In addition, this experiment is indeed based on a laboratory study using wet soaking and oscillation to allow sufficient mixing between the soil and the amendment to ensure uniform reliability of the measurements, rather than a localised result. We have indicated that the sampling site was located in Pingxiang, Jiangxi, a region with wide distribution of acidic red and yellow soils in southern China, and the soil samples taken for the experiment were precisely the soils of the local agricultural land, Please see Page 3 line 50-56. The soil samples taken for the experiment were agricultural soils in the area.

> environmental health（Xu, 2015）. Acidic soils are found worldwide, primarily in the warm and humid southern regions of China, with Jiangxi Province being a typical example (Zhu et al., 2024). Hu et al., (2024) analyzed data from 13,424 surface soil samples in Jiangxi Province, revealing that the average pH value of the topsoil in farmlands is 5.21, with a more pronounced acidity in the central areas where the pH can drop to around 4, indicating a severe soil acidification issue in this region (Hu et al., 2024).

Moreover, the soil samples had problems common to acidic soils: low pH, loss of saline ions, low soil fertility, and release of Al ions (line 57-68).

We conducted a laboratory experiment to test the effects of adding amendments to these three problems. Although it has not been put into practice in the field, the amendment did improve the quality of the acidic soil, and some potting experiments may follow to verify this. Thanks again for your useful suggestions!!! Below we have carefully revised the manuscript based on your suggestions.

> Soil acidification, caused by increased concentrations of $H^+$ or $Al^{3+}$, presents several major issues. Firstly, the soil acidification causes the leaching of base cations and the degradation of nutrients. For example, the competition between $H^+$ and $Al^{3+}$ ions and essential nutrients such as $Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$, and other nutrient ions for exchange sites leads to leaching and a decline in soil fertility (Alekseeva et al., 2011; Holland et al., 2018; Huang et al., 2017). Secondly, acidic conditions increase aluminum solubility, making plants more likely to absorb aluminum ions while hindering the uptake of key nutrients like $Ca^{2+}$ and $Mg^{2+}$, leading to toxicity (Alekseeva et al., 2011; Goulding, 2016; Nguyen, 2023). Thirdly, soil acidification activates heavy metal ions in the soil, raising the risk of heavy metal pollution (Hu et al., 2024). It also decreases organic matter content and weakens the soil structure, making it susceptible to degradation (Xu, 2015).

## Title

I suggest revising the title. It sounds a bit AI-generated. Also, please don´t use abbreviation in the title.

**Response/action:** Done, we have revised the title.

*A method for improving pH and nutrient status of acidic soils: application of a mixture of basalt powder, calcium oxide CaO and polyacrylamide.*

## Abstract

In general, the abstract contains parts which are not clear. It does not do a good job to in presenting the relevance and novelty of the study and shows only a very generic conclusion. See details below.

Line 32 – 33: How can you say something about the effectiveness? The XRF-analysis gives you data about the mineralogical composition but no information about relationships.

**Response/action:** Firstly, I apologize for any confusion in the description of the data. XRF is a method for determining the chemical composition of basalt powder, while mineral composition is achieved through XRD analysis. By comparing the sample's spectrum with that of known minerals, it is possible to identify which minerals are present in the sample. The relationship between nutritional supplementation and the chemical and mineral composition of basalt powder is as follows: the weathering of minerals releases the elements that make up their structure. The chemical composition indicates that basalt powder contains a variety of nutritional elements, and the abundance of these elements can to some extent indicate the potential for supplementation. The mineral composition is one of the determining factors for weathering. Felsic rocks, such as granite, weather more slowly than mafic rocks, such as basalt, due to differences in mineral composition (Deer et al., 2013). Based on the mineral composition, we can determine that basalt powder is more susceptible to weathering compared to other rock powders, which implies a faster rate of supplementation compared to other rock powders.

References cited:

Deer, W. A., Howie, R. A., and Zussman, J.: An introduction to the rock-forming minerals, Mineral. Soc. Lond. Bull. https://doi.org/10.1180/DHZ, 2013.

Line 40: Does the formation of acids due to basalt powder weathering counteract the pH buffering effects in your sample?

**Response/action:** Due to the restructuring of the summary, we have deleted this section as appropriate. We have revised the relevant discussion.

> the adjustment of soil pH levels. Additionally, the addition of basalt powder can increase the soil pH and soil's acid damage capacity, too, because the basalt powder reacts with carbonic acid in the soil solution, neutralizing the soil acid during this process (Swoboda et al., 2022; Dietzen and Rosing, 2023). However, it is important to

ine 41: Your data and analysis do not allow you to state something about mechanistic processes. Your results are purely descriptive and your sample size is very small to draw conclusion about specific processes.

**Response/action:** Due to the complexity and diversity of soil components, most experiments involving soil must be replicated to reduce experimental error. In this study, in order to reduce the experimental error, we pretreated soil samples by grinding, sieving and other homogenization, and carried out soil amendents research using sample from the same location. We set 2 repeat groups in the early acid improvement experiment (Table. R1), and the experimental results showed negligible experimental error, so we did not set repeat groups for every condition in the subsequent experiment, which was our negligence. Thanks for your reminding, we will emphasize and pay attention to this point in the future work. We have indicated that the sampling site was collected from Pingxiang, Jiangxi, a typical region with wide distribution of acidic red and yellow soils in southern China, and the soil samples taken for the experiment were precisely the soils of the local agricultural land (line 50-56).

Table. R1 The pH of replicate groups from preliminary experiments.

| Name | ① | ② | ③ | SD（%） |
|---|---|---|---|---|
| Control group | 4.16 | 4.11 | 4.12 | 1.63 |
| BCP910 | 6.26 | 6.3 | 6.28 | 1.63 |
| BCP820 | 7.53 | 7.49 | 7.48 | 0.21 |
| BCP730 | 7.86 | 7.82 | 7.85 | 0.17 |

Notes：The **control group** consists solely of soil; BCP910, 820, and 730 involve the addition of 1% mineral powder to the soil.

**BCP910** contains basalt powder and CaO in a 9:1 ratio, without the addition of PAM; **BCP820** contains basalt powder and CaO in an 8:2 ratio, without the addition of PAM; **BCP730** contains basalt powder and CaO in a 7:3 ratio, without the addition of PAM. ①,②,③ represent three replicate groups. **SD** stands for standard deviation.

environmental health （Xu, 2015）. Acidic soils are found worldwide, primarily in the warm and humid southern regions of China, with Jiangxi Province being a typical example (Zhu et al., 2024). Hu et al., (2024) analyzed data from 13,424 surface soil samples in Jiangxi Province, revealing that the average pH value of the topsoil in farmlands is 5.21, with a more pronounced acidity in the central areas where the pH can drop to around 4, indicating a severe soil acidification issue in this region (Hu et al., 2024).

Line 39 – 41: The basalt powder "decomposes" because of the added acid but does not produce acid during weathering.

**Response/action:** Your understanding is correct, an acidic environment does accelerate the decomposition of basalt powder, and the decomposition of basalt powder simultaneously absorbs $H^+$ from the soil.

Line 41– 43: This is a very generic conclusion of the study.

**Response/action:** We have detailed the conclusion sentence in abstract, and indicated that the study reveals the mechanisms of elements retention in soil with mixed amendment and suggests that the mixed amendment has high potential in acid soil improvement.

> limit). The study reveals the mechanisms of elements retention in soil with mixed amendment and suggests that the mixed amendment has high potential in acid soil improvement.↵

## Introduction

The introduction contains unclear statements which are too general. The statements need to be more precise and more specific. Thus, it is hard to fully comprehend the knowledge gap and the novelty of the study. Specifically, the introduction lacks clear and theory-driven research questions. It also missing testable hypothesis and a rationale which should be linked with the research gaps. After reading the introduction, the reader should be able to fully comprehend the research aim and hypothesis. However, this is not the case here. Also, the study objective is very vague. See details below.

**Response/action:** We refine the statements and mechanisms, including soil acidification (line 57-68), basalt powder weathering influencing factors (line 97-106), objectives and hypotheses, (line 121-135).

Soil acidification, caused by increased concentrations of $H^+$ or $Al^{3+}$, presents several major issues. Firstly, the soil acidification causes the leaching of base cations and the degradation of nutrients. For example, the competition between $H^+$ and $Al^{3+}$ ions and essential nutrients such as $Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$, and other nutrient ions for exchange sites leads to leaching and a decline in soil fertility (Alekseeva et al., 2011; Holland et al., 2018; Huang et al., 2017). Secondly, acidic conditions increase aluminum solubility, making plants more likely to absorb aluminum ions while hindering the uptake of key nutrients like $Ca^{2+}$ and $Mg^{2+}$, leading to toxicity (Alekseeva et al., 2011; Goulding, 2016; Nguyen, 2023). Thirdly, soil acidification activates heavy metal ions in the soil, raising the risk of heavy metal pollution (Hu et al., 2024). It also decreases organic matter content and weakens the soil structure, making it susceptible to degradation (Xu, 2015).

quality (Anda et al., 2015). The weathering of SRPs can provide nutrients for soil and this process was affected by factors like temperature, particle size, mineral composition, and pH. Higher temperatures and larger water can accelerate the weathering process (Kump et al., 2000; Weil and Brady, 2017; Swoboda et al., 2022). Smaller particle sizes increase the reactive surface area, thereby enhancing the weathering process, too. (Gillman et al., 2002). Additionally, lower pH values also increase dissolution rates of SRPs (Celimar Dalmora et al., 2020). Felsic rocks like granite weather more slowly than mafic rocks like basalt due to differences in their mineral composition (Deer et al., 2013). SRPs are well-suited for humid tropical regions due to these factors (Leonardos et al., 1987; van Straaten, 2006).

These amendments are frequently applied in combination to more comprehensively improve acidic soil properties (Zhang et al., 2023). For instance, Guo (2020) reported that combining limestone, zeolite, phosphate rock, calcium magnesium phosphate, mushroom residue, or pig manure in multi-metal contaminated acidic soils can reduce the bioavailability of heavy metals, increase soil pH, enhance fertility, and improve bacterial diversity, thus promoting the recovery of soil quality. Theoretically, these materials have complementary strengths and weaknesses. The material ratio of mixed amendment is a critical factor affecting the soil improvement, especially for the preparation of high-efficiency, low-coat, and environmentally friendly mixed amendment by common materials at optimal ratios need further study. Herein, widely used materials including $CaO$, basalt powder, and PAM were selected to prepare a mixed amendments on acidic soil improvement. The aim of this study was to explore the effects and underlying mechanisms of the mixed amendment application on typical acid yellow soil, especially in the increase of soil pH values, leaching of exchangeable base cations, potential for fertility replenishment, and reducing of aluminum toxicity.

Line 46 – 47: The first sentence sounds weird and reads like a AI-generated text. Please revise. Please explain the link of soil degradation and human productivity.

**Response/action:** Done, we have revised the sentence.

The complex interaction between soil quality and plant growth constitutes a fundamental aspect of sustainable agriculture, carrying significant implications for global food security (Nischith and Kavitha, 2024). Soil acidification is a significant indicator of soil quality degradation, impacting agricultural productivity and environmental health （Xu, 2015）. Acidic soils are found worldwide, primarily in the

References cited:

Nischith, B. J. and Kavitha, R.: THE IMPACT OF SOIL QUALITY ON PLANT GROWTH AND CROP YIELDS. Int. Res. J. Mod. Eng. Technol. Sci .06, https://www.doi.org/10.56726/IRJMETS50204, 2024.

Xu, R.K.: Research progresses in soil acidification and its control. Soil. 47, 238-244, https://doi.org

/ 10.13758/j.cnki.tr.2015.02.007, 2015.

Line 46 – 65: This section is very general and unspecific. What is the key message and how is it related to your study?

**Response/action:** This paragraph describes several problems with acidic soils. We have revised this section in the new manuscript.

> Soil acidification, caused by increased concentrations of $H^+$ or $Al^{3+}$, presents several major issues. Firstly, the soil acidification causes the leaching of base cations and the degradation of nutrients. For example, the competition between H+ and $Al^{3+}$ ions and essential nutrients such as $Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$, and other nutrient ions for exchange sites leads to leaching and a decline in soil fertility (Alekseeva et al., 2011; Holland et al., 2018; Huang et al., 2017). Secondly, acidic conditions increase aluminum solubility, making plants more likely to absorb aluminum ions while hindering the uptake of key nutrients like $Ca^{2+}$ and $Mg^{2+}$, leading to toxicity (Alekseeva et al., 2011; Goulding, 2016; Nguyen, 2023). Thirdly, soil acidification activates heavy metal ions in the soil, raising the risk of heavy metal pollution (Hu et al., 2024). It also decreases organic matter content and weakens the soil structure, making it susceptible to degradation (Xu, 2015).

Line 72: What about the other two amendments you mentioned earlier (mixed and composite amendments)? Why are there not explained in more detail here?

**Response/action:** During our literature research, we found that there was no clear distinction between mixed and composite amendments, which were basically considered to be synergistic application of multiple single amendments. Therefore, this section was modified and supplemented (line 70-76).

associated with acidic soils (Garbowski et al., 2023). Acid soil modifiers primarily consist of lime modifiers (e.g., CaO, limestone, and slaked lime), minerals (e.g., basalt powder and hydroxyapatite), industrial by-products (e.g., phosphogypsum, fly ash, and alkali residue), and organic modifiers (e.g., biochar and polyacrylamide (PAM)) (Aquino et al., 2020; Liu et al., 2022; Sun et al., 2020). Among these amendments, lime-based materials, silicate rock powders, and organic polymers exhibit significant advantages in soil improvement due to their unique properties.

Line 73 – 77: What are the main results from the cited studies and how do they relate to your study? Can there a knowledge gap derived from those studies? Also, please revise wording.

**Response/action:** The cited studies indicated that lime was a widely used soil amendments due to its advantages in acid soil improvement. Our study was focused on preparing low-cost and highly efficiency mixed amendment using common materials, such as lime. In the sited studies, researchers used lime as single soil amendment for the acid soil improvement. In our study, we use line as the primary material for mixed amendment, and other two materials (basalt powder and polyacrylamide) were added in the mixed amendment. We have revised the sentence (line 121-135).

These amendments are frequently applied in combination to more comprehensively improve acidic soil properties (Zhang et al., 2023). For instance, Guo (2020) reported that combining limestone, zeolite, phosphate rock, calcium magnesium phosphate, mushroom residue, or pig manure in multi-metal contaminated acidic soils can reduce the bioavailability of heavy metals, increase soil pH, enhance fertility, and improve bacterial diversity, thus promoting the recovery of soil quality. Theoretically, these materials have complementary strengths and weaknesses. The material ratio of mixed amendment is a critical factor affecting the soil improvement, especially for the preparation of high-efficiency, low-coat, and environmentally friendly mixed amendment by common materials at optimal ratios need further study. Herein, widely used materials including CaO, basalt powder, and PAM were selected to prepare a mixed amendments on acidic soil improvement. The aim of this study was to explore the effects and underlying mechanisms of the mixed amendment application on typical acid yellow soil, especially in the increase of soil pH values, leaching of exchangeable base cations, potential for fertility replenishment, and reducing of aluminum toxicity.

Line 87 – 89: Does this mean that the effect are known but not the mechanistic process behind?

**Response/action:** In fact, the application of silicate rock powder in agriculture is quite widespread, mainly in terms of effect manifestation. The mechanism is primarily related to weathering, and we have supplemented this in our revised manuscript, which will be addressed in the response to the next question.

Line 90 – 92: What has the data scarcity to do with the weathering rate? Hard to follow the train of thoughts. Please provide more details about the different factors (climate, mineralogy, topography, microbial activity etc.) which can impact the weathering rate.

**Response/action:** We have incorporated the statement that the use of silicate rock powder is a common agricultural practice, as suggested.

SRPs are a source of phosphorus, potassium, calcium, magnesium, and micronutrients vital for plants (Ramos et al., 2022). Fine basalt powder has been shown to increase soil's negative charge and levels of beneficial elements while decreasing harmful ones, improving soil quality (Anda et al., 2015). The weathering of SRPs can provide nutrients for soil and this process was affected by factors like temperature, particle size, mineral composition, and pH. Higher temperatures and larger water can accelerate the weathering process (Kump et al., 2000; Weil and Brady, 2017; Swoboda et al., 2022). Smaller particle sizes increase the reactive surface area, thereby enhancing the weathering process, too. (Gillman et al., 2002). Additionally, lower pH values also increase dissolution rates of SRPs (Celimar Dalmora et al., 2020). Felsic rocks like granite weather more slowly than mafic rocks like basalt due to differences in their mineral composition (Deer et al., 2013). SRPs are well-suited for humid tropical regions due to these factors (Leonardos et al., 1987; van Straaten, 2006).

References cited:


Anda, M., Shamshuddin, J., & Fauziah, C.: Improving chemical properties of a highly weathered soil using finely ground basalt rocks, Catena, 124, 147-161, https://doi.org/10.1016/j.catena.2014.09.012, 2015.

Celimar Dalmora, A., Gindri Ramos, C., DA COSTA, L., Müller Kautzmann, R., & Silva Oliveira, L. F.: Understanding the mobility of potential nutrients in rock mining by-products: An opportunity for more sustainable agriculture and mining, Sci. Total Environ., 710, 136240, 2020.

Deer, W. A., Howie, R. A., & Zussman, J.: An introduction to the rock-forming minerals, Mineral. Soc. Lond. Bull., https://doi.org/10.1180/DHZ, 2013.

Kump, L. R., Brantley, S. L., & Arthur, M. A.: Chemical weathering, atmospheric CO2, and climate, Annu. Rev. Earth Planet. Sci., 28, 611-667, https://doi.org/10.1146/annurev.earth.28.1.611, 2000.

Leonardos, O. H., Fyfe, W. S., & Kronberg, B. I.: The use of ground rocks in laterite systems: An improvement to the use of conventional soluble fertilizers?, Chem. Geol., 60, 361-370, https://doi.org/10.1016/0009-2541(87)90143-4, 1987.

Ramos, C. G., Hower, J. C., Blanco, E., Oliveira, M. L. S., & Theodoro, S. H.: Possibilities of using silicate rock powder: An overview, Geoscience Frontiers, 13, 101185, https://doi.org/10.1016/j.gsf.2021.101185, 2022.

Swoboda, P., Döring, T. F., & Hamer, M.: Remineralizing soils? The agricultural usage of silicate rock powders: A review, Sci. Total Environ., 807, 150976, https://doi.org/10.1016/j.scitotenv.2021.150976, 2022.

Van Straaten, P.: Farming with rocks and minerals: challenges and opportunities, An. Acad. Bras. Ciênc., 78, 731-747, https://doi.org/10.1590/S0001-37652006000400009, 2006.

Brady, N. C., Weil, R. R., & Weil, R. R.: The nature and properties of soils, Prentice Hall Upper Saddle River, NJ, https://doi.org/10.1016/S0065-2113(03)82003-5, 2008.

Line 95: What do you mean with "environmental sustainability" in this context?

**Response/action:** The original intention is that silicate rock powder is an environmentally friendly material. As a result of the changes to the introduction as a whole, we removed this sentence.

Line 97 – 98: Please revise wording.

**Response/action:** Done. We've deleted this sentence because of previous changes.

Line 98 – 99: Please explain "principles of environmental sustainability".

**Response/action:** The term "environmental sustainability" in this context refers to the high efficiency of polymer soil amendments without causing damage to the environment, achieving high efficiency and pollution-free outcomes.

Line 99 – 100: What is PAM? More details needed.

**Response/action:** Polyacrylamide (PAM) is a widely used high polymer known for its efficient flocculation properties, making it valuable in wastewater treatment, paper-making, oil recovery, and soil amendment applications (line 109-111).

> enhancement. Polyacrylamide (PAM) is a widely used high polymer known for its efficient flocculation properties, making it valuable in wastewater treatment, paper-making, oil recovery, and soil amendment applications (Ma et al., 2017). Previous

Line 108 – 109: Be more specific. This sentence is just a filler with no informative value. Line 113 – 116: Needs references.

**Response/action:** In order to make the logic of the objective clearer, we have modified the introduction for content (line 121-135). Basalt is a common stone material, quicklime is a common lime product, and PAM is also a commonly used agent for treating sewage and soil. They are harmless in terms of composition, readily available for purchase, and not expensive.

These amendments are frequently applied in combination to more comprehensively improve acidic soil properties (Zhang et al., 2023). For instance, Guo (2020) reported that combining limestone, zeolite, phosphate rock, calcium magnesium phosphate, mushroom residue, or pig manure in multi-metal contaminated acidic soils can reduce the bioavailability of heavy metals, increase soil pH, enhance fertility, and improve bacterial diversity, thus promoting the recovery of soil quality. Theoretically, these materials have complementary strengths and weaknesses. The material ratio of mixed amendment is a critical factor affecting the soil improvement, especially for the preparation of high-efficiency, low-coat, and environmentally friendly mixed amendment by common materials at optimal ratios need further study. Herein, widely used materials including CaO, basalt powder, and PAM were selected to prepare a mixed amendments on acidic soil improvement. The aim of this study was to explore the effects and underlying mechanisms of the mixed amendment application on typical acid yellow soil, especially in the increase of soil pH values, leaching of exchangeable base cations, potential for fertility replenishment, and reducing of aluminum toxicity.

## Material and methods

The experimental design is not descripted very clear and needs revision. The overall sample size and the sample size of the test groups are not mentioned. There are no statistical analysis described at all. Based on your data, simple ANOVA and/ or Random fixed models would be suitable to back up your conclusions. See details below.

**Response/action:** Changes were made to the experimental design, as seen in the specific answers to the questions below. The way in which the data were statistically analysed was not carried out, given that the trend in the experimental results was quite clear, and will be considered in the continued revision of the manuscript.

Line 120: What soil classification system are you using? What exactly is yellow loam?

**Response/action:** The classification system comes from the book 《Chinese Soil Classification System》(1992), which is a method of classification formed from the actual situation of Chinese soils. Huang soil belongs to the iron-aluminum soil class and the warm iron-aluminum soil subclass within it. It develops in the warm and humid subtropical climate zone, characterized by low organic matter content, low fertility, yellow color, and strong acidity.

References cited:

Gong Zitong, Editor; Editorial Board of Chinese Soil System Classification Research Series, Editor. Exploration of Chinese Soil System Classification [M]. Beijing: Science Press, 1992.

Line 124: What do you mean with "> 98% lime powder" and why is the molecular weight of the PAM important?

**Response/action:** The content of CaO is >98%, and the molecular weight of PAM determines its flocculation strength. The PAM we selected for our experiment is a commonly used type, and here we simply provide an explanation of the reagent. We have simplified this section (142-145).

> The experiment used CaO with a purity over 98% and polyacrylamide with a molecular weight exceeding 3 million. The basalt powder, with a pH of 9.71 and particle size under 38 μm, was made from rocks (Figure 1.) collected in Hui li, Sichuan,

Line 125 – 126: More explanation needed on the preliminary experiments.

**Response/action:** The reason for selecting basalt powder in this section is: We obtained five basalt samples during our field collection, and since the composition of the basalt samples did not differ significantly, we measured the pH value of the five samples and chose the one with the highest pH value as the experimental material. Perhaps it is not very necessary to present this part, and according to the suggestion of another reviewer, we have removed it.

Line 126: What do you mean with "original basalt samples"?

**Response/action:** "Original basalt samples" refer to the block-shaped samples of basalt collected from the field.

Line 127: Be more precise. What do you mean with "were pulverized to a particle size"?

**Response/action:** This is the treatment we conducted on the block-shaped basalt rock samples, which were ground into powder using a grinding machine. The process is shown in Figure 1.

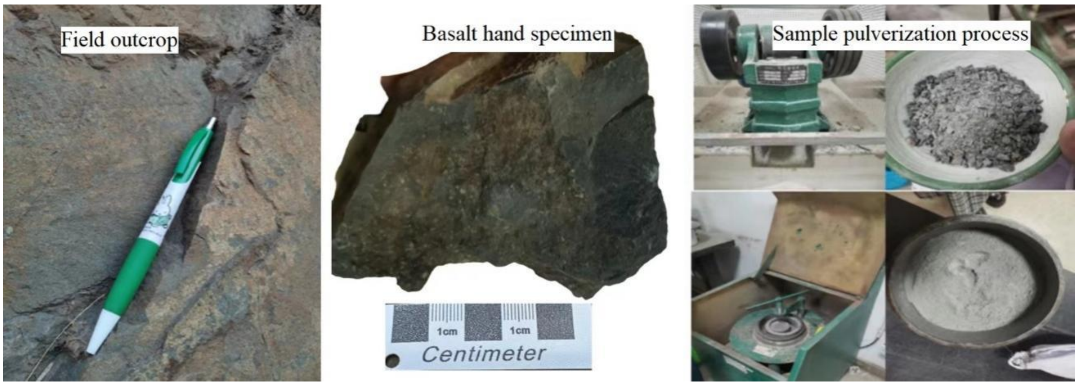


Figure 1 Collection and production of basalt powder

Line 128 – 131: Hard to understand.

**Response/action:** This is the selection process for basalt powder, which we have removed.

Line 132: Please provide more details for the XRF analysis. A more detailed description of the working steps is needed.

**Response/action:** We can provide the specific steps for XRF analysis, but we believe this is not the focus of our research, so we have omitted the description of this process. If you think it is necessary to supplement this section with this content, we will add it in later.

Specific operational steps can be found in the book "X-ray Fluorescence Spectrometry: Second Edition" by John Chaston. A brief summary is that the process involves mixing the sample to be tested with boric acid and then pressing it under high pressure into a uniform thin wafer, which helps standardize the sample form and reduce variability during testing. Subsequently, the formed wafer is placed into the XRF instrument, where X-rays are used to excite the elements in the sample to produce characteristic fluorescence. The intensity of this fluorescence is measured to quantitatively analyze the elemental composition of the sample.

Line 136 – 139: I do not understand this. Please revise. Line 140 – 142: Study aims belongs more to the introduction section. Line 145: More details about the additive proportions. Be specific. Line 145 – 148: Please revise wording.

**Response/action:** We added the purpose of the experiment in the introduction section and deleted it here. We have reflected the information about the added proportions in detail, also Table 3 should not be overlooked.

> Preliminary experiments on the ratio of basalt powder to CaO suggested that when the basalt powder ratio was greater than 90%, the soil pH was less than 6, and when the basalt powder ratio was less than 60%, the soil pH was greater than 9. Therefore, the proportions of basalt powder were set to 90%, 80%, and 70% for further experimentation. To independently assess the influence of PAM, the series of experiments with basalt powder to CaO ratios of 9:1, 8:2, and 7:3 were set to both PAM-amended and non-amended groups, as well as a control group with only soil (Table 3).

Line 153: Why is the suspension left for 2 days?

**Response/action:** This process ensures thorough reaction between the soil solution and the amendment agents.

Line 154: More information needed about the test groups.

**Response/action:** The issue has been addressed and revised in the previous response.

Line 156 – 160: Is this the same for all soil and crop types?

**Response/action:** Yes, you can understand it in this way, but the concept was originally proposed for acidic soils, as their tolerance to acidity is of greater concern. The reason for setting this indicator is that when the soil pH is below 3.5, it is almost unsuitable for the survival of most plants. This indicator can measure the acid tolerance of acidic soils. We have moved this section to the methods.

> et al., 2013; Fan et al., 2018). Additionally, the acid damage capacity, which is the amount of acid required to lower the soil pH to 3.5 (μmol·g-1, adding common acid rain acids such as $H_2SO_4$)(Wang, Jinghua, 1994; Ma et al., 2020), is used to evaluate the soil's resistance to acidification. The leaching of exchangeable base cations and

Line 161: Unnecessary filler sentence. Delete it..

**Response/action:** Done. We have delete this sentence.

Line 164: How was the soil pH measured?

**Response/action:** We used a PHS-3E pH meter to measure the pH value of the soil suspension and indicated in manuscript.

Line 165 – 168: Was this done for all samples and amendments? More explanation needed.

**Response/action:** When measuring the initial pH value, there is no need to add acid; however, acid is added during subsequent tests for acidifying capacity and acid buffer capacity, as well as when studying the impact of acid addition on the release of cationic nutrients and aluminum ions.

Line 170: Filler sentence. Delete it.

**Response/action:** Done. We have delete this sentence.

Line 173 – 174: Why was the suspension settled for 2 days and then agitated again?

**Response/action:** Leaving it to stand for two days ensures adequate reaction with the solution, and shaking it again ensures the homogeneity of the solution.

Line 176: How was the predetermined acid quantity calculated?

**Response/action:** We did not preset the amount of acid to be added. We added acid in small increments until the measured pH value fell below 3.5.

Line 177 – 178: More explanation needed.

**Response/action:** Firstly, the adsorption experiment of PAM was conducted because we observed different behaviors of various ions in the acid leaching experiment during the base cation leaching tests, with some anomalies occurring. For instance, with the addition of PAM, there was a slight increase in the leaching of $K^+$ and $Na^+$, while the leaching of $Ca^{2+}$, $Mg^{2+}$, and $Al^{3+}$ decreased (line 266-267). We noticed that this pattern seemed to be related to the valence of the ions and speculated that it was related to the adsorption effect of PAM, so we supplemented this experiment. We prepared standard solutions of sodium, potassium, calcium, magnesium, and aluminum, added PAM, and after shaking and then allowing them to stand for two days to ensure adsorption equilibrium was reached. The ion content in the supernatant was measured after centrifugation (line 200-207).

group. However, with the addition of PAM, there was a slight increase in the leaching of $K^+$ and $Na^+$, while the leaching of $Ca^{2+}$, $Mg^{2+}$, and $Al^{3+}$ decreased. Thirdly, the

To provide a more comprehensive explanation of the ion leaching results, adsorption experiments of PAM on ions and the ion release of basalt powder. In the ion adsorption experiment of PAM, a mixture was prepared using the PAM solution and ion standard solution. The resulting mixture had a PAM concentration of $8\times10^{-5}$ g·ml$^{-1}$ and contained $K^+$, $Na^+$, $Ca^{2+}$, $Mg^{2+}$ and $Al^{3+}$ at concentrations of 100 μg·ml$^{-1}$, 100 μg·ml$^{-1}$, 100 μg·ml$^{-1}$, 100 μg·ml$^{-1}$,20 μg·ml$^{-1}$, respectively. To ensure the adsorption equilibrium was achieved, the mixture was allowed to stand undisturbed for a period of 2 days. In the experiment of ion release from basalt powder, add 0, 100, 200, 300, 400,

## Results

The main issue with the results are the missing statistical analysis. The observed trends are not back-upped by any statistics thus there is no confidence behind the conclusion. Thus, how can the authors be sure that the trends they see are significant and not just coincidence? See details below.

**Response/action:** As mentioned in the previous responses, 1) our soil samples underwent homogenization preprocessing such as grinding and sieving. Preliminary repeated experiments for pH improvement conditions (Table R1) indicated that errors due to the complexity and heterogeneity of soil components could be neglected, hence we did not conduct repetitions for each condition in subsequent experiments; 2) our soil is collected from a typical lateritic yellow soil in Jiangxi, which is highly representative; 3) our paper focuses solely on the mechanism by which the mixed additive amends the acidity and improves the loss of salts in typical acidic yellow soils in our country, thus the sample collection is relatively singular, and all experiments revolve around the research topic. For instance, to address the acid improvement, we set up six groups of experiments with different ratios, which is not a small number; 4) the results indicate that the soil additive we developed has good effects on acid improvement and salt retention, and the paper provides reasonable explanations for these effects in conjunction with other previous studies. Therefore, we believe our data is correct, and the patterns demonstrated by the experiments are accurate.

Line 190 – 192: This is just a filler and has no informative value. Delete it.

**Response/action:** Done. We deleted it.

Line 195 – 196: This is interesting but not relevant for your study.

**Response/action:** Serpentine is formed from pyroxene and other magnesium-rich minerals through hydrothermal alteration, and it has a higher magnesium-iron content than its parent minerals. Since basalt's main components include pyroxene, it can be inferred to some extent that basalt subjected to hydrothermal alteration may more readily form magnesium-iron-rich serpentine, which weathers more easily. This could potentially save time in mineral identification.

Line 197 – 198: Filler sentence. Delete it.

**Response/action:** We think this sentence can be left out because we need to elicit the table of chemical compositions (Table 4).

Line 198 – 200: This is no surprise since basalt is a silicate rock. Silicate oxides are the main component of every silicate rock.

**Response/action:** You are right, although it is a fact, put here as a description of the data, that even if they are all basalts, the percentage of silicate oxides is not exactly the same.

Line 200 – 202: More details needed since too generic.

**Response/action:** Here are the detailed benefits of silicon for crops; due to space constraints, we need to consider whether it is necessary to include these details in the manuscript.

The significance of Si accumulation in plants lies in its ability to alleviate the toxicity of specific heavy metals such as Cd, Cu, Zn, and As. Silicon treatment in plants reduces Mn toxicity as Si enhances Mn binding to cell walls, thereby limiting its cytoplasmic concentration (Liang et al., 2007; Rogalla and Romheld, 2002).

Moreover, Si enhances the uptake of essential nutrients like K, P, and Ca. Early studies suggest that under phosphorus deficiency, the effect of Si could be due to an in planta mechanism, implying an improved utilization of P, likely through increased phosphorylation (Cheong and Chan, 1973) or a decrease in Mn concentration (Ma and

Takahashi, 1990). Mali and Aery (2008a) noted that even at low Si concentrations, K uptake is improved through the activation of H-ATPase. They also observed better absorption of N and Ca in cowpea and wheat fertilized with increasing doses of sodium metasilicate (50–800 mg/kg Si), as well as improved nodulation and apparently better N2 fixation in cowpea (Mali and Aery, 2008a, 2008b).

Si also mitigates the impacts of drought. Wheat plants subjected to drought and treated with Si maintained higher stomatal conductance, relative water content, and water potential than non-treated plants. Larger and thicker leaves limit water loss through transpiration (Gong et al., 2003; Hattori et al., 2005) and reduce water consumption (Eneji et al., 2005).

Furthermore, Si bolsters crop resilience against pathogens and pests. The beneficial effects of Si are attributed to the precipitation of amorphous SiO2 in plants, acting as a mechanical barrier (Cheng, 1982), contributing to the plant's overall defense against various biotic stresses.

References cited:

Rogalla H, Romheld V (2002): Role of leaf apoplast in silicon-mediated manganese tolerance of Cucumis sativus L. Plant Cell and Environment. 25:549-555

Cheong YWY, Chan PY (1973): Incorporation of P32 in phosphate esters of the sugar cane plant and the effect of Si and Al on the distribution of these esters. Plant and Soil. 38:113-123

Ma JF, Takahashi E (1990): The effect of silicic acid on rice in a P-deficient soil. Plant and Soil. 126:121-125

Mali M, Aery NC (2008a) : Influence of silicon on growth, relative water contents and uptake of silicon, calcium and potassium in wheat grown in nutrient solution. Journal of Plant Nutrition. 31:1867-1876

Gong HJ, Chen KM, Chen GC, Wang SM, Zhang CL (2003): Effects of silicon on growth of wheat under drought. Journal of Plant Nutrition. 26:1055-1063

Hattori T, Inanaga H, Araki H, An P, Morita S, Luxova M, Lux A (2005): Application of silicon enhanced drought tolerance in Sorghum bicolor. Physiol Plant. 123:459-466

Eneji E, Inanaga S, Muranaka S, Li J, An P, Hattori T, Tsuji W (2005): Effect of calcium silicate on growth and dry matter yield of Chloris gayana and Sorghum sudanense under two soil water regimes.

Grass and Forage Science. 60:393-398

Cheng BT (1982): Some significant functions of silicon to higher-plants. Journal of Plant Nutrition. 5:1345-1353

Liang YC, Sun WC, Zhu YG, Christie P (2007): Mechanisms of silicon-mediated alleviation of abiotic stresses in higher plants: a review. Environ Pollut. 147:422-428

Line 204 – 211: Hard to follow. Please revise wording.

**Response/action:** We have made revisions (line 230-235).

> et al., 2012; Rinder and Hagke, 2021). P, K, Mg, and Ca are the major nutrients required for plant growth. Fe is an essential micronutrient for plant development. Additionally, Na and Ti are beneficial elements that enhance plant growth. Beyond the elements included in the primary mineral composition of basalt powder, there are accessory elements necessary for the formation of secondary minerals or present within the mineral lattice through isomorphism (Table 4).

Line 207: There are no chemical formulas in Figure 2.

**Response/action:** We have made revisions (line 230-235).

Line 208: Is the isomorphism relevant for your study?

**Response/action:** This indicates that although these elements are not included in the chemical formula of our minerals, they exist within the mineral lattice through isomorphous substitution, and the weathering process can also release them.

Line 213: Please improve wording.

**Response/action:** We have made revisions.

*Different compositions of the amendment significantly increased the soil pH value by at least 2 units (Fig.3a).*

Line 219 – 220: Hard to follow. Revise.

**Response/action:** We have explained why it is necessary to adjust the soil pH to near-neutral levels in the introduction section (line 149-153). This section has also been revised (line 244-247).

> fluorescence (XRF) analyses. The assessment of pH values is achieved by comparing the numerical changes before and after the addition of materials, using different ratios of CaO and basalt. The optimal effect is determined by adjusting the pH value to a near-neutral range (6.5-7.5), suitable for the growth of most plants and microorganisms(Tang et al., 2013; Fan et al., 2018). Additionally, the acid damage capacity, which is the

> The data indicates that only BCP821 and BCP820, with a basalt powder to CaO ratio of 8:2, adjusted the soil pH to near neutrality. Having achieved the goal of pH regulation, we selected BCP821 and BCP820 for base cation and aluminum ion leaching experiments.

Line 220 – 223: This belongs to the method section.

**Response/action:** We have deleted and supplemented in the introduction section (line 153-156).

> et al., 2013; Fan et al., 2018). Additionally, the acid damage capacity, which is the amount of acid required to lower the soil pH to 3.5 (μmol·g-1, adding common acid rain acids such as $H_2SO_4$)(Wang， Jinghua, 1994; Ma et al., 2020), is used to evaluate the soil's resistance to acidification. The leaching of exchangeable base cations and

Line 224: What is the unit here?

**Response/action:** Thank you for pointing that out; we have added the units ( μ mol/g).

In general, those code names for the test groups are not informative at all. I suggest coming up with more descriptive names for the groups.

**Response/action:** In Table 3, we have carefully described the amendment addition information for these group names. The letters BCP each represent basalt powder, CaO, and PAM, respectively. Using the initials as codes should be clear.

**Table 3** Experimental groups and corresponding codes

| Amendments (mg/g) | Control | BCP910 | BCP820 | BCP730 | BCP911 | BCP821 | BCP731 |
|---|---|---|---|---|---|---|---|
| Basalt powder | 0 | 9 | 8 | 7 | 9 | 8 | 7 |
| CaO | 0 | 1 | 2 | 3 | 1 | 2 | 3 |
| PAM | 0 | 0 | 0 | 0 | 0.002 | 0.002 | 0.002 |

Line 225 – 229: Since there are no statistics beyond the results, you cannot rule out other potential factors, which could impact those buffer curves. Why not using random fixed models for testing the significance? This section also contains already interpretations.

**Response/action:** We have already stated that the soil samples were treated to be homogeneous and stable, and we consider the data to be reliable. We have explained the reason why the addition of basalt powder and CaO can significantly improve the soil's buffering capacity against acid, and indicated that *the basalt powder reacts with carbonic acid in the soil solution, neutralizing the soil acid during this process (Swoboda et al., 2022; Dietzen and Rosing, 2023).*

Line 237 – 243: This section lacks references and already contains interpretations, which do not belong to the result section.

**Response/action:** We will move this part to the discussion section. And additional references has been provided.

> the adjustment of soil pH levels. Additionally, the addition of basalt powder can increase the soil pH and soil's acid damage capacity, too, because the basalt powder reacts with carbonic acid in the soil solution, neutralizing the soil acid during this process (Swoboda et al., 2022; Dietzen and Rosing, 2023). However, it is important to

Reference cited:

Line 240 – 242: Isn´t this trivial? This is to be expected when you add acid to your samples. This is part of the method, no? And why is it a gradual decomposition? Wouldn´t it be more interesting to focus how many elements were retained from leaching due to amendments?

**Response/action:** Yes, it is to be expected for the increase of base salt ions and aluminum ions leaching amounts when adding acid to samples. And the test for leaching amounts of base salt ions and aluminum ions with the addition of acid was to explore the potential of mixed amendment on the salt ions retention. The amounts of elements retained from leaching due to amendments was also an important data and immediately introduced.

Line 244 – 255: Again, how much confidence do you have in your results and conclusions? You simply can´t know, if the trends you see a statistically relevant since no statistical analysis were done. In addition, the sample size is nowhere stated in the manuscript. How big is your sample size? How representative is your dataset? Is the dataset solid enough to draw meaningful conclusions out of it. Frankly, I doubt it.

**Response/action:** As mentioned in the previous responses, 1) our soil samples underwent homogenization preprocessing such as grinding and sieving. Preliminary repeated experiments for pH improvement conditions (Table R1) indicated that errors due to the complexity and heterogeneity of soil components could be neglected, hence we did not conduct repetitions for each condition in subsequent experiments; 2) our soil is collected from a typical lateritic yellow soil in Jiangxi, which is highly representative; 3) our paper focuses solely on the mechanism by which the mixed additive amends the acidity and improves the loss of salts in typical acidic yellow soils in our country, thus the sample collection is relatively singular, and all experiments revolve around the research topic. For instance, to address the acid improvement, we set up six groups of experiments with different ratios, which is not a small number; 4) the results indicate that the soil additive we developed has good effects on acid improvement and salt retention, and the paper provides reasonable explanations for these effects in conjunction with other previous studies. Therefore, we believe our data is correct, and the patterns demonstrated by the experiments are accurate.

Discussion

The discussion lacks a clear storyline. The authors should emphasize on what we have learned and how this connects with the hypothesis. However, the argumentation is hard to follow and contains many speculative and over-simplified parts. Many conclusions are not supported by the data. See details below.

**Response/action:** Thank you for your comments. We have revised the overall structure of the article, providing a clearer description of the relationship between the current state of research and the purpose of our study in the introduction and methods sections, as well as the indicators we used to achieve our goals. In the discussion section, we have corresponded with the purpose of the study, hoping that it will be clearer to read. Details are in the responses to your questions below, as well as in the new manuscript.

Line 257: This section header doesn´t make any sense.

**Response/action:** Because the mineral composition and particle size of basalt are important factors affecting weathering and element release. Our discussion of this section also revolves around this topic. We have changed the title to: " *Advantages of mineral structure for basalt powder in soil nutrients supplementing* "?

Line 258 – 260: This statement is supported by what data? And what would be the consequence?

**Response/action:** Regarding this issue, an explanation has been stated in the introduction.

> SRPs are a source of phosphorus, potassium, calcium, magnesium, and micronutrients vital for plants (Ramos et al., 2022). Fine basalt powder has been shown to increase soil's negative charge and levels of beneficial elements while decreasing harmful ones, improving soil quality (Anda et al., 2015). The weathering of SRPs can

Line 260 – 262: This is over-simplified. Weathering processes and their influencing factors a way more complicated than presented here.

**Response/action:** We have refined this content in the introduction.

improving soil quality (Anda et al., 2015). The weathering of SRPs can provide nutrients for soil and this process was affected by factors like temperature, particle size, mineral composition, and pH. Higher temperatures and larger water fluxes can accelerate the weathering process (Kump et al., 2000; Weil and Brady, 2017; Swoboda et al., 2022). Smaller particle sizes increase the reactive surface area, thereby enhancing the weathering process, too. (Gillman et al., 2002). Additionally, lower pH values also increase dissolution rates of SRPs (Celimar Dalmora et al., 2020). Felsic rocks like granite weather more slowly than mafic rocks like basalt due to differences in their mineral composition (Deer et al., 2013). SRPs are well-suited for humid tropical regions due to these factors (Leonardos et al., 1987; van Straaten, 2006).

Line 262: Do you mean experimental instead of statistical analysis? Line 263 – 266: Al-containing silicate rocks could be literally everything. The diversity of silicate rocks in the upper crust is huge. This statement has no informative value. Line 265 – 266: Over-simplified. There are many more factors driving weathering rates.

**Response/action to the three：** Apologies for any confusion caused; this is a conclusion drawn from a statistical perspective in other researchers' work. In response to these three issues, we have further refined this part of the content in our manuscript.

Line 268: These are not metallic bonds. Line 269 – 271: References are missing.

**Response/action:** Thank you for pointing out, it should be "ionic bonds". The patterns of bond energy are inferred from the periodic law of elements, and variations in bond energy can indeed be one of the factors affecting the ease of weathering. Since we have rewritten this section, the content has been revised. The revised version is as follows:

4.1 Advantages of mineral structure for basalt powder in soil nutrients supplementing

The weathering of basalt led to the liberation of nutrient elements inherent in the rock, thereby enriching the soil's nutritional content (Ramos et al., 2022). Mineral XRD analysis indicates that the main mineral composition of basalt is: pyroxene ($(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$), feldspar($(Na,K,Ca)Al_2Si_3O_8$), serpentine ($(Mg,Fe)_3(Si_2O_5)(OH)_4$). Previous studies have shown that iron-magnesium minerals such as serpentine and pyroxene are easily weathered (Deer et al., 2013; Swoboda et al., 2022), especially under acidic conditions (Rinder and Hagke, 2021). Under acidic conditions, silicate minerals absorb $H^+$ from the soil, decomposing and releasing nutrient element ions (Deer et al., 2013; McBride, 1994). Our acid leaching experiment with basalt can also prove this (Figure 7), where during the acid soaking process, alkali metal ions are released, effectively replenishing soil fertility.

Reference sited:


Ramos, C. G., Querol, X., Oliveira, M. L. S., Pires, K., Kautzmann, R. M., and Oliveira, L. F. S.: A preliminary evaluation of volcanic rock powder for application in agriculture as soil a remineralizer, Sci. Total Environ., 512-513, 371-380, 2015.

Deer, W.A., Howie, R.A., Zussman, J.: An Introduction to the Rock-Forming Minerals. Mineralogical Society of Great Britain and Ireland, https://doi.org/10.1180/DHZ, 2013.

Swoboda, P., Döring, T.F., Hamer, M.: Remineralizing soils? The agricultural usage of silicate rock powders: A review. Sci. Total Environ. 807, 150976, https://doi.org/10.1016/j.scitotenv.2021.150976, 2022.

Rinder, T., Hagke, C.V.: The influence of particle size on the potential of enhanced basalt weathering for carbon dioxide removal - Insights from a regional assessment. J. Cleaner Prod. 315, 128178, https://doi.org/10.1016/j.jclepro.2021.128178, 2021.

McBride, M.B: Environmental chemistry of soils. Oxford University Press, New York, 1994.


Line 271 – 276: This is over-simplified again. Basaltic rocks are highly diverse in their geochemical composition thus elemental composition based on their geo-tectonical settings in which they have formed.

**Response/action:** Okay, we've found some duplication in this paragraph with what has already been depicted and have rewritten the relevant portion in the hope that it will improve.

Line 277 – 278: Bad wording and typos. Please revise.

**Response/action:** Due to the rewriting of the paragraph, we have removed it.

Line 279 – 287: How are those statements related to your study? What is the take-home-message here. What can the reader learn from this?

**Response/action:** This paragraph analyzes the weathering rate from the perspective of particle size. In our materials and methods, we mentioned that our basalt powder is below 38μm. Previous research has shown that a reduction in particle size can effectively increase the weathering rate by an order of magnitude (doubling), and our basalt powder with such a small particle size has an enhanced weathering rate. Does this mean that it dissolves immediately, and its effectiveness over time cannot be guaranteed? Therefore, we cited the experimental results of previous studies on the dissolution of basalt powders of different particle sizes, proving their longevity.

Particle size of minerals is a key factor in determining the rate of weathering, as smaller particles have a larger specific surface area, which means a greater contact area with the soil solution, leading to more complete reactions (Swoboda et al., 2022). Research by Vanderkloot and Ryan (2023) indicates that particles smaller than 45μm weather at a rate twice as fast as particles sized 150-500μm. From this, we can deduce that the weathering rate of minerals is almost inversely proportional to their particle size. In our experiment, the basalt powder used has a particle size smaller than 38μm. Does this imply that the weathering rate is too fast to have a long-lasting effect in the soil? Anda et al., (2015) conducted a long-term experimental study (24 months) using basalt powder with a particle size smaller than 50μm, and the data showed that the soil pH value gradually increased throughout the process (from 3.9 to 6.5). Rinder and Hagke (2021) predicted the dissolution of basalt powder of different particle sizes in the soil over a period of 10 years using a weathering model. The results showed that for the scale of 10-100μm, the predicted weathering is 16%. Although the weathering rate in the natural environment is several times that in the soil (Swoboda et al., 2022), it also proves the long-term effectiveness of basalt powder.

Line 289: Basalt contain also a large amount of Ca-rich feldspars.

**Response/action:** Indeed, the feldspar in the basalt powder used in the experiment is calcium-rich, and its weathering rate is slower compared to magnesium-rich minerals, but it is only part of the mineral composition. From Figure 7, we can also see that after adding a certain amount of acid, the ion release tends to stabilize. This also proves that some minerals have not been weathered in a short period of time. This can demonstrate the long-term effectiveness of the basalt powder.

Line 288 – 292: This statement is based on what data? Also revise wording. Minerals undergo weathering but do not actively drive weathering processes. This part also contains speculative parts. Line 292 – 294: Too simple. You don´t provide solid data for that statement.

**Response/action:** In the revised manuscript, we have provided a more detailed and clear description, which has been provided in the aforementioned text.

Line 303 – 305: However, Figure 5 show that leaching still occurs. So how meaningful is this 300 % increase in acid damage capacity? How is the acid damage capacity calculated anyway? It is not described in detail in the methodology.

**Response/action:** Figure 5 shows the change in ion release during the acid addition process. We cannot ignore that the source of these ions includes the dissolution of basalt powder (Figure 7), while $Ca^{2+}$ is mainly related to the dissolution of quicklime. If we observe the initial point, i.e., the group without added acid, in a nearly neutral environment, the weathering of basalt is relatively slow, and not many ions are released. At this time, we can see that the ion leaching reagent added with the amendment has decreased (the increase in $Ca^{2+}$ is due to the rapid dissolution of CaO). Regarding the acid damage capacity, which is represented by the amount of $H^+$ moles consumed to decrease the pH value of 1g of soil to 3.5, our calculation is the moles of consumed sulfuric acid multiplied by 2 (since one mole of sulfuric acid contains 2 mol H+), divided by the mass of the soil.

Line 306 – 307: This is quite a blunt statement. You simply claim positive correlations are present in your data without having done any correlation analysis or any other statistical analysis in your study at all. Figure 3 does not allow you to make any statements about correlations since it is not a scatter plot but a bar chart. You could do ANOVAS here.

**Response/action:** Your suggestion is very effective. The reason we did not conduct a correlation analysis is that we believe the conclusion is relatively straightforward. Basalt has an inherent pH of 9, and the quantity added is minimal; it requires dissolution to absorb $H^+$. Moreover, in our preliminary experiments, we tried using only basalt powder to amend soil pH, and found that varying the amount of basalt powder had a very slight impact on soil pH, a similar effect is observed with PAM. Additionally, 1 mole of CaO dissolved in water can produce 2 mol $OH^-$. Taking BCP821 as an example, the CaO in it can supply $7.3 * 10^{-5}$ moles of $OH^-$ per gram of soil. We are adding the ANOVAS in revised manuscript.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Line 311 – 313: Where is the data for this statement?

**Response/action:** We explain here that the weathering of basalt powder can neutralize soil acid.

> the adjustment of soil pH levels. Additionally, the addition of basalt powder can increase the soil pH and soil's acid damage capacity, too, because the basalt powder reacts with carbonic acid in the soil solution, neutralizing the soil acid during this process (Swoboda et al., 2022; Dietzen and Rosing, 2023). However, it is important to

Line 314 – 319: Hard to follow. Revise wording.

**Response/action:** We have revised the wording in manuscript. We mentioned that the lower the pH value, the faster the weathering of basalt powder. The rapid increase in soil pH due to CaO slows down the weathering of basalt powder. However, when the soil is later subjected to acid erosion, the weathering of basalt can absorb $H^+$ again. This indicates that our material is not a short-term amendment but has a lasting effect on soil improvement.

> ($(Mg,Fe)_3(Si_2O_5)(OH)_4$). Previous studies have shown that iron-magnesium minerals such as serpentine and pyroxene are easily weathered (Deer et al., 2013; Swoboda et al., 2022), especially under acidic conditions (Rinder and Hagke, 2021). Under acidic

> process (Swoboda et al., 2022). The rapid increase in soil pH after the application of lime hinders the weathering process of basalt powder, thereby indicating that this amendment agent has durability. The release of $OH^-$ serves to increase the soil pH value,

Line 321 – 324: This belongs to the appendix then.

**Response/action:** We have moved this section to the Materials and Methods chapter.

> To provide a more comprehensive explanation of the ion leaching results, adsorption experiments of PAM on ions and the ion release of basalt powder. In the ion

Line 325 – 373: I suggest re-writing the discussion part. Many part a hard to follow, missing references and contain speculation. Try to focus on what the reader can learn from your data. What is the key message of your study.

**Response/action:** Thank you for your detailed suggestions; we will further refine the discussion section. The key message of our study was that we successfully prepared a mixed amendment to improve the acid soil quality. And the mixed amendment can significantly increase the soil pH and soil acid damage capacity, reduce the leaching of nutrients and aluminum toxicity.

Conclusion

This is a summary but not a conclusion.

**Response/action:** Thanks for pointing this out, we've made some changes and look forward to your more detailed suggestions!

> This study examines the impact of a combination of basalt powder, CaO, and PAM mixed modifier on acid soil improvement. The findings indicated that the optimal pH adjustment effect (4.16 to 6.86) was achieved when the ratio of basalt powder to CaO is 8 to 2. Furthermore, the application of the mixed modifier demonstrated the potential for soil nutrition supplementing, significantly increased the soil's acid-damage capacity (20.3 mmol/kg), reduced the leaching of $K^+$(58.1%), $Na^+$(42.9%), $Mg^{2+}$(26.3%), $Al^{3+}$ (100%), and accordingly decreased the soil's aluminum toxicity. The results suggested that the combined utilization of these three modifiers holds promise for improving the quality of acidic soil. However, variations in the chemical composition and mineral structure of silicate rocks across different regions result in distinct properties of soil. Consequently, it is imperative to conduct further research tailored to the specific local conditions

**Author contribution**

I´m curious. Since all authors did supervision, were there other potential co-authors involved in the study (PhD students for example)?

**Response/action:** All co-authors of this paper are listed, and other contributions are acknowledged.


> Investigation Program [2022FY100202]. Thank Prof. Zhu Xiaoping of Chengdu University of Science and Technology for her guidance in the experiments.


Figures and tables

In general, the captions are not very informative to the reader. What is the key message of ach display item?

**Response/action:** We believe that the title should convey the information presented in the chart. If you have specific suggestions for revision, we will adopt them.

Table 1: Revise table. What is the difference of the upper and the lower part of the table? Is there an error with the column headers?

**Response/action:** We have modified Table 1.

**Table 1** Mechanical composition of tested soil.

| Composition | Clay | | Powder | | | Sand | |
|---|---|---|---|---|---|---|---|
| Size (mm) | <0.005 | 0.01~0.005 | 0.05~0.01 | 0.075~0.01 | 0.25~0.075 | 0.5~0.25 | 1.0~0.5 |
| Content (%) | 43.1 | 11.1 | 28.8 | 5.6 | 9.4 | 0.9 | 1.1 |

Table 2: What is the sample size? What about replicates?

**Response/action:** The data in this table come from previously published article. We used soil that was sampled and processed from a unified batch.

classified as yellow loam. The soil exhibited a pH value of 4.16, an organic matter content of 12.91 mg/kg (Zhang et al., 2022). The mechanical and chemical compositions are presented in Table 1 and Table 2.

Table 3: The codes are not informative. I suggest more descriptive names for the groups.

**Response/action:** The header row indicates the group numbers, and the header column represents the types of materials. For example, BCP910 signifies basalt powder at 9mg/g (9mg per gram of soil), CaO at 1mg/g, and PAM at 0.

Figure 1: Unnecessary. What would be the key message or guidance for the reader here?

**Response/action:** The key information is about the origin of our basalt powder, from the field outcrops to the block samples, and then to the powder.

Figure 3: How was the acid damage capacity calculated? What´s the sample size?

**Response/action:** We have already described this clearly in the introduction. Please see Page 6 Line 142-144. The issue of sample size has been explained in the previous text. Our samples are uniform, stable, and representative.

Figure 5: Why are only two test groups presented? How do you explain that less elements are leached when adding acid?

**Response/action:** We have excluded other experimental groups based on the pH adjustment effect and retained BCP820 and BCP821 (line 244-247). The mechanism of ion leaching is also explained in the discussion section (Page 14-16).

> The data indicates that only BCP821 and BCP820, with a basalt powder to CaO ratio of 8:2, adjusted the soil pH to near neutrality. Having achieved the goal of pH regulation, we selected BCP821 and BCP820 for base cation and aluminum ion leaching experiments.

Figure 6: This figure is based on what testing groups? There are three groups with PAM addition. How was the adsorption rate calculated? This figure is not described in the results.

**Response/action:** In the Materials and Methods section, we introduced the steps of the adsorption experiment (line 20-207). This is an experiment to test the adsorption of PAM on salt base ions and aluminum ions. Standard solutions of ions are added to PAM, shaken evenly, and allowed to stand to ensure equilibrium of the reaction. After centrifugation, the ion concentration is measured. The adsorption rate is calculated by comparing the difference between the original concentration of the standard solution and the concentration of the solution after centrifugation to the original solution concentration.

> To provide a more comprehensive explanation of the ion leaching results, adsorption experiments of PAM on ions and the ion release of basalt powder. In the ion adsorption experiment of PAM, a mixture was prepared using the PAM solution and ion standard solution. The resulting mixture had a PAM concentration of $8\times10^{-5}$ g·ml$^{-1}$ and contained $K^+$, $Na^+$, $Ca^{2+}$, $Mg^{2+}$ and $Al^{3+}$ at concentrations of 100 μg·ml$^{-1}$, 100 μg·ml$^{-1}$, 100 μg·ml$^{-1}$, 100 μg·ml$^{-1}$,20 μg·ml$^{-1}$, respectively. To ensure the adsorption equilibrium was achieved, the mixture was allowed to stand undisturbed for a period of 2 days. In the experiment of ion release from basalt powder, add 0, 100, 200, 300, 400,

Figure 7: What was the soil pH here? Please explain "neutral acidic conditions". I mean,

the pH changes anyway by adding the acid, no? This item is also not described in the result section.

**Response/action:** Thank you for your careful pointing out. There was a mistake in the description. What we meant was the change in ion leaching during the acid addition process. The manuscript has been corrected. Additionally, this is an acid leaching experiment of basalt powder, which is not related to the soil. It is an independent experiment conducted to verify the extent to which the ion changes in the soil samples amended with the improver are influenced by the dissolution of basalt.

**Figure 7** Ion leaching of basalt powder during the acid addition process.