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Effect of Combined Use of Organic Crop Growth Enhancer, Inorganic and Organic Fertilizers on the Proximate Quality of Maize (Zea Mays L.)

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ABSTRACT

This study investigated the use of organic crop-growth enhancers by farmers to improve the proximate quality of maize (*Zea mays* L.) in Ghana. Multi-location field trials at CSIR-CRI Fumesua and AAMUSTED Mampong over the two rainy seasons of 2023 were conducted. The proximate quality was evaluated from two perspectives: the location where the maize was cultivated and the specific crop growth enhancer that was applied. A Randomized Complete Block Design with twelve treatments and each replicated four times was used. The treatments were T1 = Agro charger, T2 = Agro clean, T3 = Agro charger +Agro clean, T4 = NPK, T5= NPK + Agro charger, T6 = NPK + Agro clean, T7= NPK + Agro charger + Agro clean, T8 = Poultry manure (PM), T9 = PM +Agro charger, T10 = PM+ Agro clean, T11 = PM + Agro charger +Agro clean, T12 = control. The results showed that across both locations, the proximate quality (protein, moisture content, carbohydrate, crude fibre content, fat and total ash) of maize was superior at Fumesua compared to Mampong. Furthermore, in relation to the treatments applied, poultry manure and the addition of Agro charger, as well as the combination of poultry manure+ + Agro charger + Agro clean, resulted in the best proximate quality in cultivated maize. The study recommends the use of PM + Agro charger + Agro clean for higher maize growth and yield.

INTRODUCTION

Maize (Zea mays L.) is one of the most important cereal crops globally, ranking third after rice and wheat (Neupane et al., 2022). It is a staple food for over six hundred million people in Sub-Saharan Africa (Benjamin, 2024) and is crucial for food security in Ghana, where it accounts for 50-60% of the country's cereal production (Obour et al., 2022) and provides a per capita consumption of 43.8 kg/head (Wongnaa et al., 2021). Despite its importance, Ghana's national average maize yield of 2.48 MT/ha is less than a third of the achievable 7-8 MT/ha, a disparity attributed to factors such as low fertilizer use, which is 22.6 kg ha-1 (Avatim et al., 2021), and poor nutrient utilization (Obour et al., 2022). Traditionally, maize production has relied on inorganic fertilizers like nitrogen (N) to boost growth and yield (Amfo and Ali, 2021). However, the high cost of inorganic fertilizers, inefficient nutrient absorption, and environmental concerns like leaching have limited their use, especially among smallholder farmers (Penuelas et al., 2023; Obour et al., 2022). Organic materials like poultry manure have shown promise in improving soil properties and crop growth, but their bulky nature and laborious application limit their adoption by smallholder farmers (Aboutayeb et al., 2014; Agbede, 2025). By combining these innovative nanoparticles with traditional inorganic and organic fertilizers, it is possible to create a more efficient and sustainable approach to maize production, mitigating the limitations of each method (Dubey, 2016; Deepak and Yogeshavari, 2019). In Ghana, maize production is primarily rain-fed and carried out by poorly resourced smallholder farmers, making it vulnerable to abiotic factors like insufficient water and inefficient nitrogen utilization (ASABE, 2016; Hafiz et al., 2022). Although individual applications of inorganic fertilizers, organic manures, and nanoparticles have been studied, the synergistic effects of their combined use on the proximate

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quality of maize grains have not been thoroughly investigated. Therefore, this study aims to address this knowledge gap by evaluating how the integrated use of combining organic crop-growth enhancers, inorganic, and organic fertilizers affects the nutritional (proximate) quality of maize, providing valuable insights for developing more effective and sustainable maize production strategies.

METHODOLOGY: THE STUDY AREA STUDY AREA AND PERIOD

The research was multi-location field trials conducted at CSIR-CRI Fumesua and AAMUSTED Mampong over two rainy seasons of 2023 in Ghana. Certified maize seeds, Opeaburo (Hybrid, white), were obtained from CSIRCRI research station at Fumesua, Ghana, for planting. Opeaburo (Hybrid, white) white hybrid maize, which is a short-duration (110 days) released by CSIR -CRI. It is recognized for its high-yielding potential and is often compared to other popular varieties in Ghana.

Sample Preparation

For data collection, simple-random sampling was employed within each plot's harvestable area, where five plants were randomly selected and tagged for maize grain samples to be taken to the Soil Science Laboratory for proximate analysis.

Experimental Design

A multi-location field experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Treatments were randomly allocated to experimental plots in a Randomized Complete Block Design (RCBD). The experiment field had a total of forty-eight (48) plots. The total field size measured was 57.6 m x 26 m, (1497.6 m^2). Each experimental plot measured 4.8 m wide x 5 m long (24 m). Plant spacing between and within rows was 80 cm x 40 cm, respectively. Before planting, poultry manure (layer manure) at the rate of 10 t/ha (3% N = 300 kg N/ha) was incorporated into the beds two weeks before planting. The Agro Charger (ACH) is an organic crop-growth booster (nanomaterial) that is mostly made of botanical extracts. Its mechanism of action is to enhance the efficiency of nutrient uptake in the plant and improve the soil quality in general. It does this through the enhancement of Cation and Anion Exchange Capacities (CEC/AEC) of the soil, which render existing nutrients more bioavailable. Agro Clean (ACL) is an organic plant protector and stress manager, as well that is based on botanical extracts. It is a pesticide, it acts as a protection in the exterior of the plants against environmental stress and infection by sucking pests, bacteria and fungi (Halpern et al., 2015; Boruah et al., 2025).

Table 1: Treatments provided the combination of mineral fertilizers doses and urea.

TREATMENT	AMENDMENT	APPLICATION RATE
T1	Agro Charger (ACH)	296 ml per 148 L water/ha
T2	Agro Clean (ACL)	296 ml per 148 L water/ha
T3	ACH + ACL	296 ml per 148 L water/ha (of each)
T4	NPK	250 kg/ha
T5	NPK + ACH	125 kg/ha + 148 ml per 74 L water/ha
T6	NPK + ACL	125 kg/ha + 148 ml per 74 L water/ha
T7	NPK + ACH + ACL	125 kg/ha + 148 ml per 74 L water/ha + 148 ml per 74 L water/ha
T8	Poultry Manure (PM)	10 t/ha
T9	PM + ACH	5 t/ha + 148 ml per 74 L water/ha
T10	PM + ACL	5 t/ha + 148 ml per 74 L water/ha
T11	PM + ACH + ACL	5 t/ha + 148 ml per 74 L water/ha + 148 ml per 74 L water/ha
T12	Control	0

A. CL= Agro clean, A. CH= Agro charger and PM= Poultry manure

Seeds were planted at a rate of two seeds per hill and later thinned to one per stand two weeks after planting.

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Agro Charger was applied at a rate of 296ml/148 water l/ha, while Agro Clean was also applied at a rate of 296ml per 148 water l/ha. Yara Activa 23-10-5 NPK-2.5 Mg-3S-0.3Zn compound fertilizer blend was applied at a rate of 250 kg/ha (5 bags/ha). The treatment combination included the same rate for both Agro charger with Agro clean at the rate 296 ml per 148 water l/ha, respectively. In addition, a Yara Activa 23-10-5 NPK-2.5 Mg3S-0.3Zn compound fertilizer blend was applied at a rate of 4.94 bags/ha (247 kg/ha). Certified Opeaburo hybrid maize seed was dibbled at 5 cm depth, two seeds per hill and thinned to one stand at 14 days after planting (DAP).

Proximate Analysis

The proximate composition of the twelve different treatments at both Mampong and Fumesua was determined using AOAC techniques to determine total ash, crude protein, carbohydrate, crude fibre, and moisture (AOAC, 1990).

Crude Fiber Content

Two grams of maize grain samples were weighed, put in a digestion flask with 200 cc of 1.25% sulfuric acid, and boiled slowly for half an hour. The residue was promptly filtered through linen and then rinsed with distilled water until it was acid-free. After re-transferring the residue to the digestion flask, 200 ml of 1.25% sodium hydroxide (NaOH) was added, and 30 minutes of heating were spent on the combination. After filtering the leftover material, it was repeatedly washed in distilled water to eliminate any remaining alkali. The residue was dried at 105 degrees and then rinsed with 15 millilitres of 95% ethanol in a porous crucible.

Until a steady weight was achieved and noted, °C.

Crude fibre percentage was determined.

$$\% \text{ Crude fiber} = \frac{(\text{Mass of fiber})}{(\text{Dry mass of sample used})} x100$$

Crude Protein Content

Digestion

A 500 ml long-necked Kjeldahl flask was filled with two grams of ground maize grain per sample. Ten millilitres of purified water and a full spatula of Kjeldahl catalyst, a mixture of one part selenium, ten parts copper sulphur, and one hundred parts sodium sulphur were added to the sample to wet it. After that, 20 ml of concentrated H_2SO_4 was added, and the mixture was further broken down until it was colourless and clear. After allowing the digest to cool, it was decanted into a 100 ml volumetric flask and filled to the brim with distilled water.

Distillation

The digested material was pipetted into a Kjeldahl distillation unit after being separated into ten millilitres (10 ml) parts. Then, 20 ml of 40% NaOH was added, followed by 90 ml of distilled water to bring the volume of the distillation flask up to 100 ml. The distillate was collected over three drops of mixed indicator and 10 ml of 4% boric acid in a 200 ml conical flask.

Titration

As the distillate was collected, about 100 millilitres were titrated with 0.1 N HCL until the blue colour changed to grey and quickly flashed pink.

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Crude protein was calculated as follows:

$$\% \text{ Nitrogen} = \frac{[(A-B)(N) X 1.4007)]}{\text{g of sample}}$$

$$\%Protein = \%Nitrogen x 6.25(Protien\ factor)$$

Where A = HCL titration for sample; B=HCL titration for blank; N=Normality of HCL.

Total Ash Content

One gram of each maize grain sample was placed in a crucible and weighed. The crucible was then placed in a furnace that was continuously set at 550 °C for five to six hours, or until the sample turned white ash. Its weight was then recorded after it had some time to cool in a desiccator.

The amount of ash in % was determined as

(A+B)-A=B

(A+C)-A=C

%Ash=(C/B) x 100

Where A=weight of crucible, B=weight of sample, C=weight of Ash

Moisture Content Determination

Each fresh sample was placed in five grams in a dish that had already been weighed. After that, the sample was dried in an oven for 24 hours at 100 °C. Once the dried samples had cooled for thirty minutes in desiccators, they were weighed again. The process was continued until a constant weight was reached. The weight difference as a percentage was calculated using the original sample's moisture content.

$$\text{Percentage moisture content} = \frac{W1 - W2}{W1} X\ 100$$

Where W1 = weight (g) of sample before drying

W2= weight (g) of sample after drying.

Crude Lipid Content

One gram of the finely-powdered sample was placed on a folded filter paper, which was then weighed. To eliminate any water absorbance, it was immersed in moisture at a constant temperature of 100 ºC for at least thirty minutes. Once it had cooled in the desiccator, it was placed in a Soxhlet apparatus. Subsequently, the apparatus was assembled onto a circular-bottomed flask containing a certain amount of petroleum ethyl, and the sample was introduced. After that, it was placed on a hot plate with a connector for input coolant coming from a tap and an output coolant flowing from the device. After an hour of boiling, the heat was reduced until there was only a thin layer of ether remaining in the flask bottom. The sample inside the folded filter paper was removed and allowed to dry for five minutes after the Soxhlet had been drained. We took the stuff out of the folder lined with filter paper and weighed it. It was then taken out of the paper, weighed, and noted.

Calculations

$$(A + B) - A = B\ \%\ \text{ether extract} = \frac{B}{C} X100$$

Where, A = flask weight, B=ether extract weight, C=sample weight

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Carbohydrate Content

The amount of carbohydrates was determined using various factors. To achieve this, the total percentage compositions of the protein, fat, fibre, and ash amounts were subtracted from 100.

Thus,

% carbohydrate =100- (% moisture +% ash+% fiber + % protein + % fat)

Statistical Analysis

Excel was used to gather and store the data. Before being entered into Statistics 9.1, the data were further organized. Analysis of variance (ANOVA) was used to analyse laboratory data. The "Tukey HSD All-PairwiseComparisons Test" was used to separate the obtained means.

RESULTS AND DISCUSSION

Location And Treatments on Protein Quality

The protein content in maize exhibited significant differences between the two locations, which ranged from 12.84% to 14.16% at Mampong and Fumesua, respectively. Moreover, the application of the combined treatments consistently improved protein quality in Fumesua compared to Mampong, which was significantly different($p<0.05$) in Figure 1. The protein content demonstrated statistically significant discrepancies between the two experimental locations, with Fumesua exhibiting higher values ranging from 11.13% to 17.00%, whereas Mampong displayed lower values ranging from 10.02% to 17.00% in Figure 2. Moreover, the treatment involving Poultry Manure combined with Agro Charger and Agro clean at Fumesua recorded the highest protein content of 17.00%, which was significantly superior to the control treatment that achieved the lowest value of

13.02%, represented. Similarly, at Mampong, the highest protein content was observed in the treatment involving N.P.K combined with Agro Charger and poultry manure combined with Agro Clean, which recorded 14.29% and 14.32% respectively, showing no significant differences, which surpassed the control treatment, which yielded the lowest value of 10.27%. The results indicate significant variations in protein percentage across different treatments and locations· For instance, the PM + A.CH + A.CL treatment yielded the highest protein content in Fumesua at 17.00%, closely followed by Agro Clean at 15.30% and N.P. K + A.CH at 15.37%· In contrast, the control group showed the lowest protein percentages, ranging from approximately 13.02% in Fumesua to 10.27% in Mampong· The overall trend suggests that combined applications of nutrients, particularly those incorporating organic components, tend to enhance maize protein quality compared to the control· This observed enhancement of protein content in maize through combined nutrient management aligns with findings in other research on biostimulants and integrated nutrient management· The scientific reason for this can be attributed to organic crop growth enhancers ("Agro charger"), which contain a rich array of amino acids, peptides, and other biologically active compounds that act as precursors for protein synthesis or enhance the enzymatic activities involved in nitrogen metabolism (Rouphael and Colla, 2020)· Additionally, these compounds can improve root development, leading to better absorption of essential nutrients, particularly nitrogen, which is a fundamental component of amino acids and proteins· Inorganic fertilizers (NPK) provide readily available macro-nutrients crucial for overall plant growth and protein formation (Havlin et al., 2020)· Organic fertilizer (poultry manure) contributes to soil health by improving its physical, chemical, and biological properties· Poultry manure releases nutrients slowly, ensuring a sustained supply for the plant, and enhances microbial activity, which can mineralize organic nitrogen into plant-available forms (Amanullah et al., 2007; Adeleye et al., 2010)· The synergistic effect observed in combined treatments, such as PM + A.CH + A.CL and N.P. K + A.CH suggests that the different inputs complement each other, providing a more balanced nutrient profile and optimizing plant physiological processes for maximum protein accumulation· Protein is essential for performing various physiological activities in our body, like muscle building, repair, and defence mechanisms·

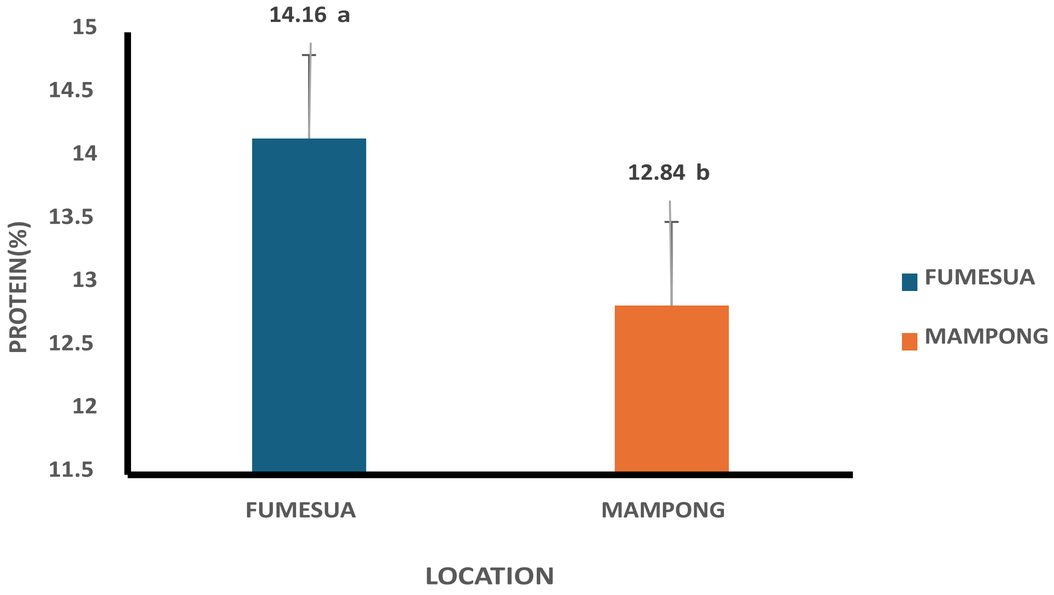

Figure 1: Protein Quality (%) of Maize (Zea Mays L) Production at Mampong and Fumesua

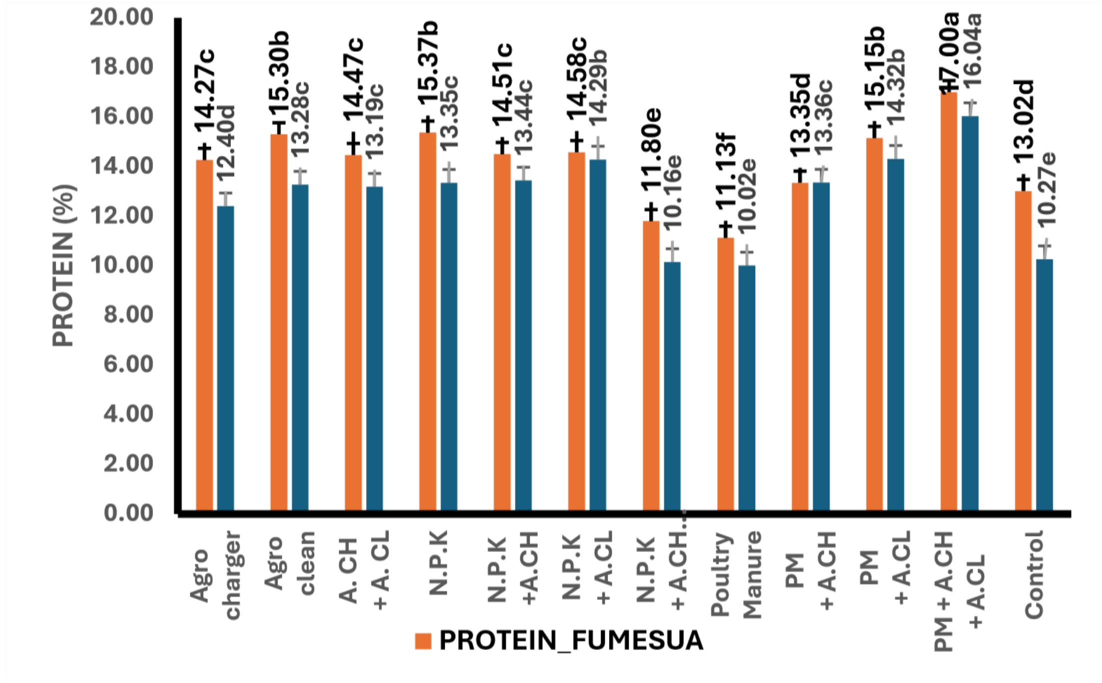

Figure 2: Protein Quality of Maize (Zea Mays L) Production Location and Treatments on Moisture Quality

The moisture content in maize exhibited significant differences *(p<0.05)* between the two locations, which ranged from 9.82% to 9.24% at Fumesua and Mampong, respectively, in Figure 3. Moreover, the application of the combined treatments consistently reduced the moisture content of maize at Mampong compared to Fumesua. Furthermore, the moisture content of maize kernels at harvest spanned from approximately 8.28% ("Agro charger") to a maximum of 10.22% (Poultry manure + Agro charger + Agro clean) in Figure 4. The moisture content of maize grain targeted for safe long-term storage typically falls within a stringent range of 12% to 15% (Ziegler, 2021; Ottonello, 2024). The consistently lower moisture levels documented in this study indicated a highly favourable harvest condition, minimizing susceptibility to fungal proliferation, insect infestation, and metabolic degradation. Optimal nutrient availability, facilitated by NPK and poultry manure, provided the necessary metabolic scaffolding for robust plant health and the proper execution of programmed senescence, which included the controlled abscission of water from the developing grain (Gan, 2014). "Agro charger" enhanced nutrient uptake efficiency and conferred improved tolerance to environmental stresses, likely promoting a more synchronous and efficient physiological maturity across the maize stand.

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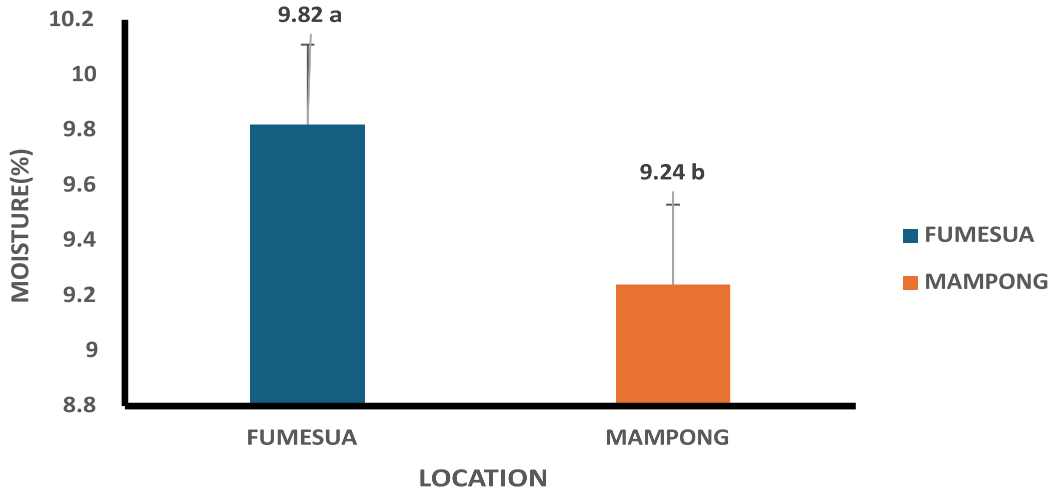

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Figure 3: Moisture quality (%) of maize (*Zea mays L*) production at Mampong and Fumesua

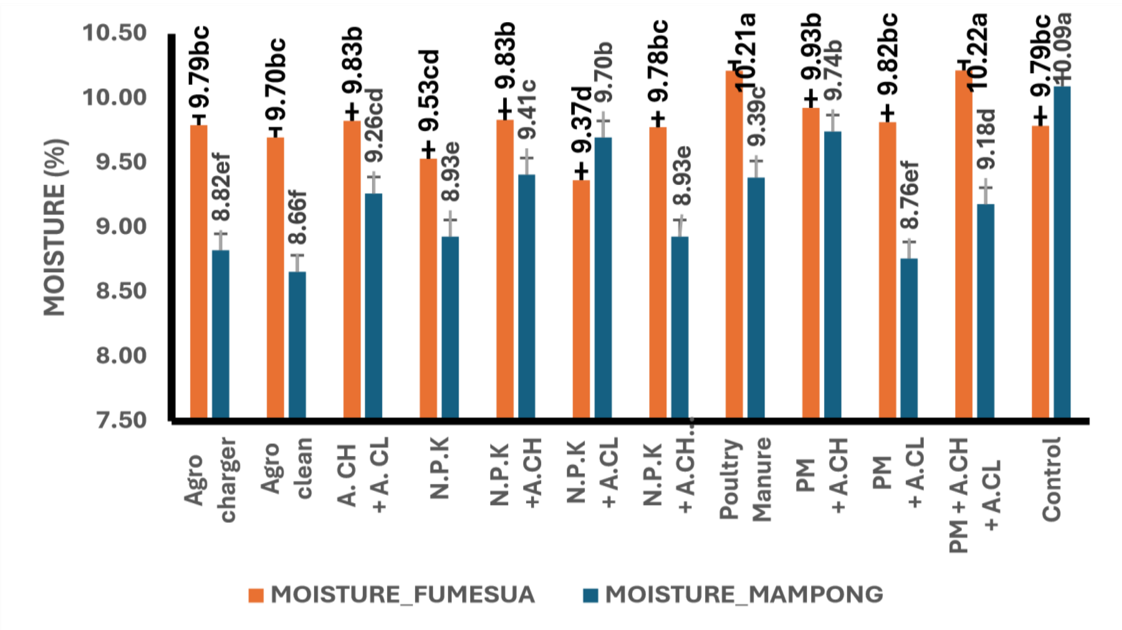

Figure 4: Moisture quality (%) of maize (Zea mays L) production LOCATION AND TREATMENTS ON CARBOHYDRATE QUALITY

The carbohydrate concentration in maize showed statistically significant discrepancies between the two sites, with values ranging from 67.8% to 65.75% at Mampong and Fumesua, respectively, as shown in Figure 5. However, the carbohydrate percentages spanned a range from approximately 63.46% (Poultry manure + Agro charger + Agro clean) to a maximum of 71.22% (NPK + Agro charger + Agro clean) in Figure 6. The carbohydrate profile of maize typically fell within 65% to 80%. The attainment of values reaching 71.22% in Mampong (NPK + Agro charger + Agro clean) highlighted the capacity of optimized fertilization strategies to significantly enhance starch accumulation. From a biochemical perspective, the fluctuations in maize carbohydrate content are intricately linked to the metabolic pathways of photosynthesis and starch biosynthesis. Nitrogen is an indispensable constituent for the synthesis of key photosynthetic enzymes and chlorophyll molecules, thereby directly dictating the efficiency of carbon assimilation (Fathi et al., 2022). NPK functions critically in energy transduction, providing the ATP necessary for photosynthesis and serving as a structural component in the starch synthesis pathway (Allen, 2002; Skillman et al., 2011). Potassium plays a multifaceted role in enzyme activation and the transport of sucrose from source leaves to the developing kernels, thereby ensuring a robust supply of precursors for starch deposition (Maathuis, 2009). "Agro charger" was posited to augment photosynthetic rates and optimize the partitioning of photo assimilates, thus favouring the enhanced biosynthesis and storage of starch within the endosperm (du Jardin, 2015).

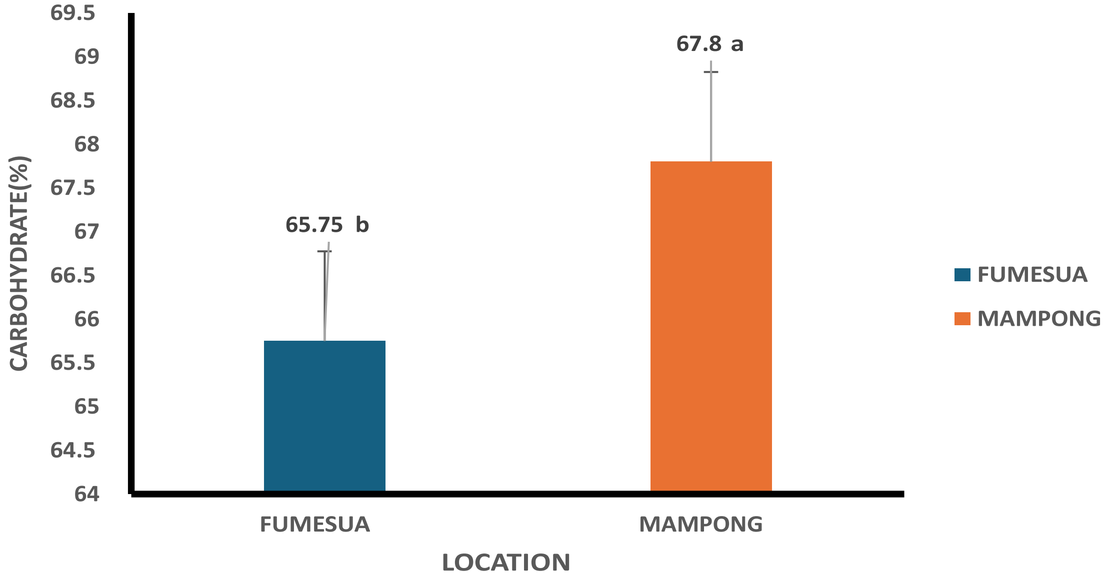

Figure 5: Carbohydrate quality (%) of maize (Zea mays L) production at Mampong and Fumesua

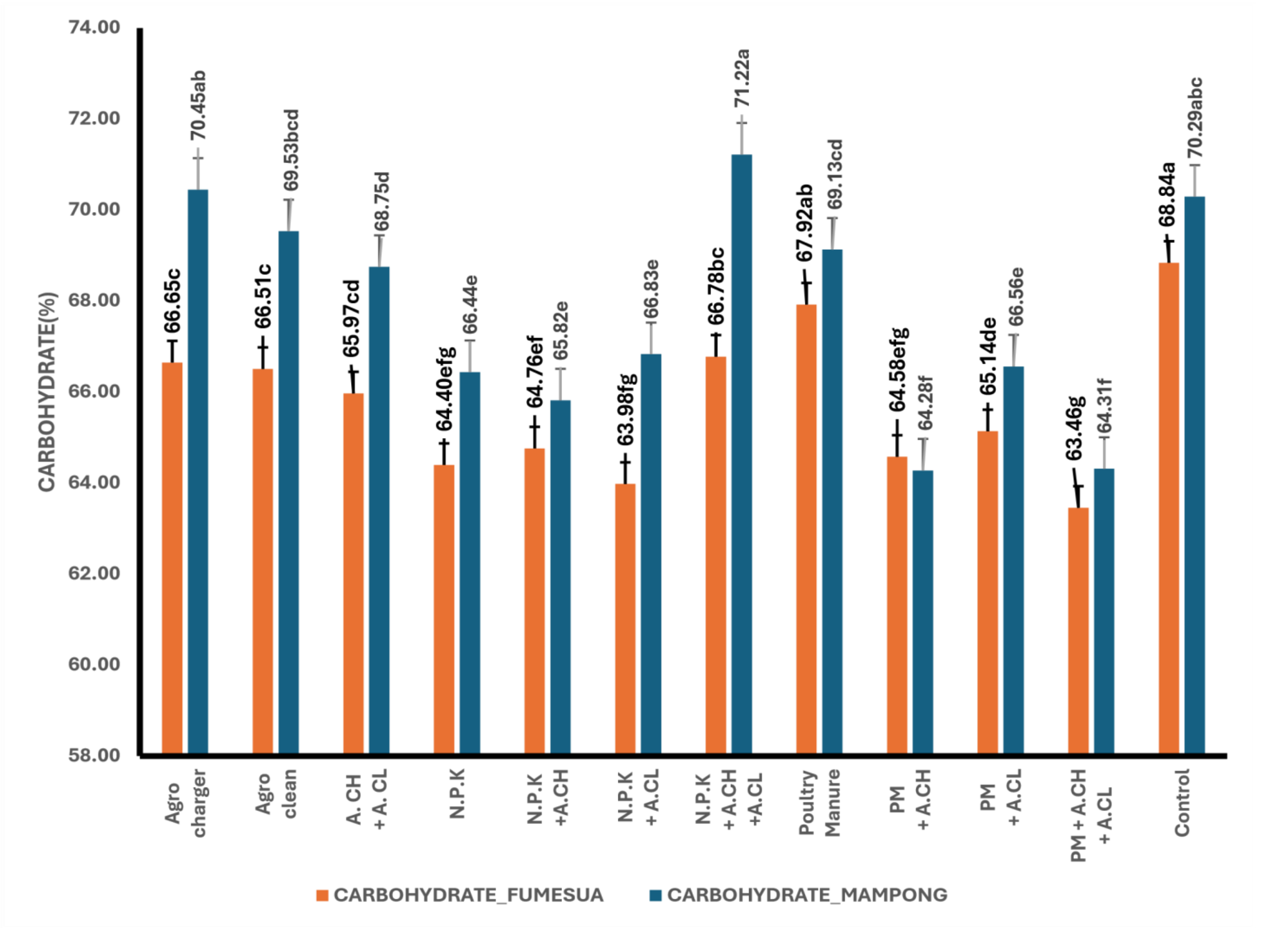

Figure 6: Carbohydrate quality (%) of maize (Zea mays L) production

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Location And Treatments on Fibre Quality

The fibre content demonstrated statistically significant *(P<0.05)* variations between the two experimental sites, with Mampong registering a higher fibre percentage of 4.54%, while Fumesua recorded a lower value of 3.98% in Figure 7. In Figure 8, the crude fibre content of maize from Fumesua and Mampong, subjected to various treatment combinations, ranged from approximately 3.41% (Fumesua, Agro charger) to 5.09% (Fumesua, NPK + Agro charger)· This observed maize crude fibre content range broadly aligns with existing literature, which typically reports values between 2% and 6% (Herbert, 2017; Kara et al., 2022)· Crude fibre, which consists of cellulose, hemicellulose, and lignin, is are structural carbohydrate forming plant cell walls· The application of NPK fertilizers provides essential macronutrients, including phosphorus and potassium, which are crucial for carbohydrate metabolism, energy transfer, and cell wall formation (Marschner, 2012)· Poultry manure contributes to improved soil structure and a sustained release of nutrients, which are vital for healthy plant development and robust cell wall formation (Diacono and Montemurro, 2010)· The "Agro charger" biostimulants enhance nutrient uptake efficiency and promote overall plant growth and vitality, facilitating the plant's capacity to synthesize these complex carbohydrates· The highest crude fibre values often correspond to treatments combining NPK or poultry manure with "Agro charger," suggesting a synergistic effect where the biostimulants optimize the utilization of nutrients provided by the fertilizers for enhanced structural carbohydrate synthesis·

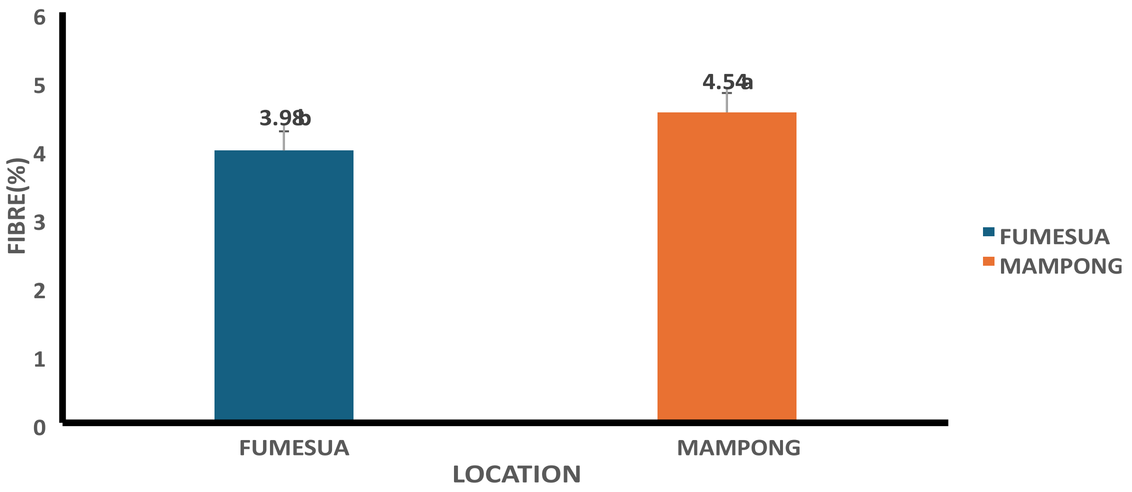

Figure 7: Fibre quality (%) of maize (Zea mays L) production at Mampong and Fumesua

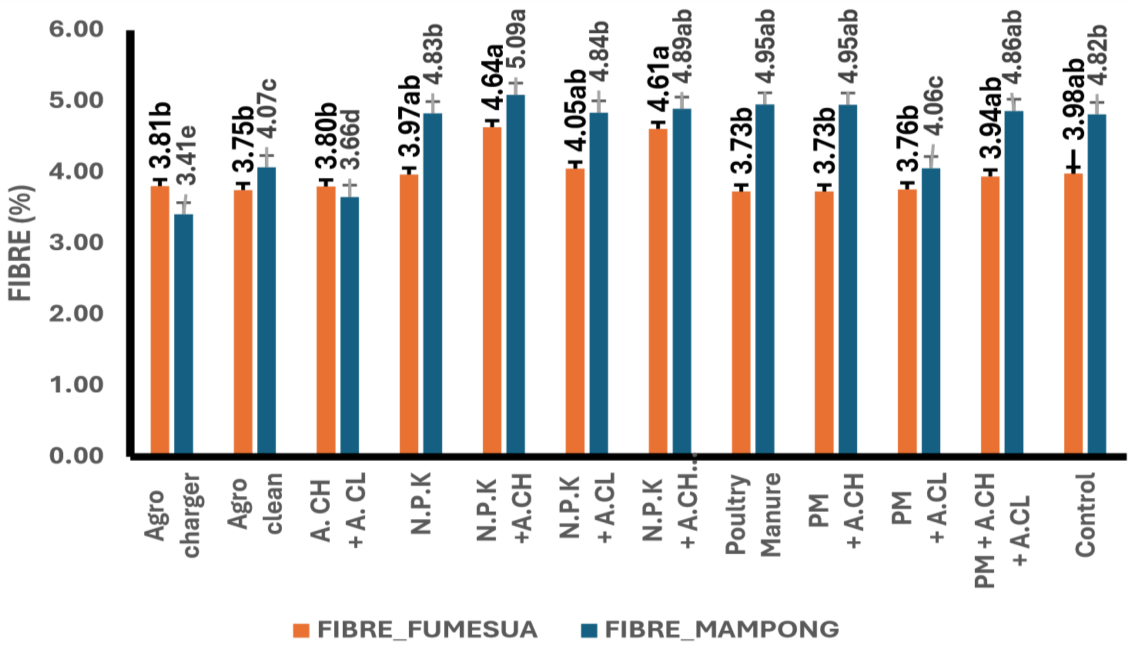

Figure 8: Fibre quality (%) of maize (Zea mays L) production Location and Treatments on Fat Quality

The fat content demonstrated no statistically significant differences *(P<0.05)* between the two locations. Fumesua (3.81%) recorded the highest fat content compared to Mampong, which recorded 3.46% in Figure 9. Furthermore, in Figure 10, the crude fat content observed in this study ranges from approximately 2.18% (Fumesua, Control) to a high of 5.66% (Fumesua, PM + Agro charger)· The crude fat content of conventional maize typically ranges between 3% and 5% (Nuss et al., 2010; Herbert, 2017)· The higher observed values, particularly 5.62% and 5.66%, demonstrate a significant enhancement, surpassing the upper limits of typical crude fat content in common maize· The biochemical basis for these variations is linked to the metabolic pathways involved in lipid synthesis, which are significantly influenced by nutrient availability and plant physiological responses to biostimulants· Crude fat in maize primarily comprises triglycerides stored in the germ, derived from fatty acid synthesis· Nitrogen, obtained from NPK and poultry manure, is critical for the synthesis of enzymes involved in fatty acid elongation and desaturation (Gastal and Lemaire, 2002; Ma et al., 2024)· Phosphorus is essential for energy transfer (ATP) required for lipid biosynthesis (Marschner, 2012)· Poultry manure provides a slow and sustained release of these macronutrients, enhancing soil microbial activity, which can indirectly support lipid synthesis· "Agro charger" and "Agro clean" improved the overall nutrient uptake efficiency and promoted robust plant metabolism, channelling a greater proportion of assimilated carbohydrates towards lipid synthesis pathways·

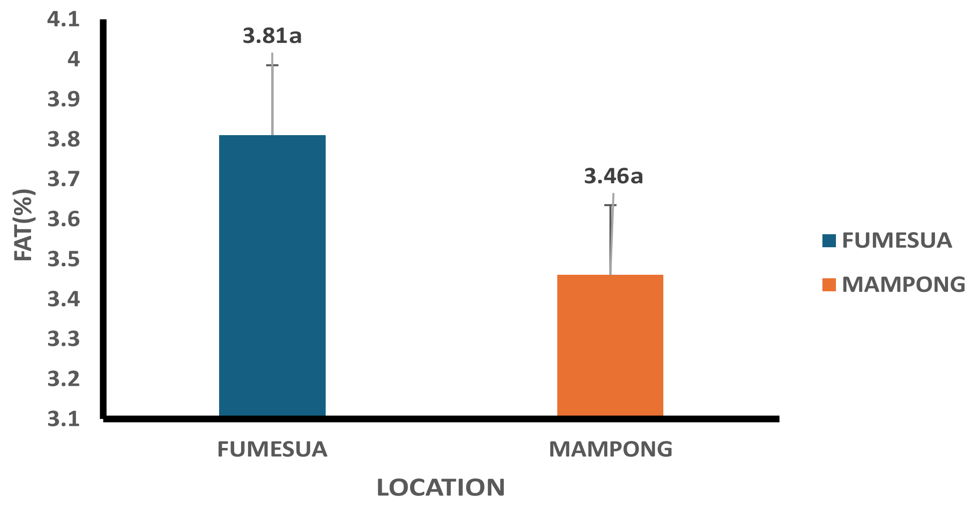

Figure 9: Fat quality (%) of maize (Zea mays L) production at Mampong and Fumesua

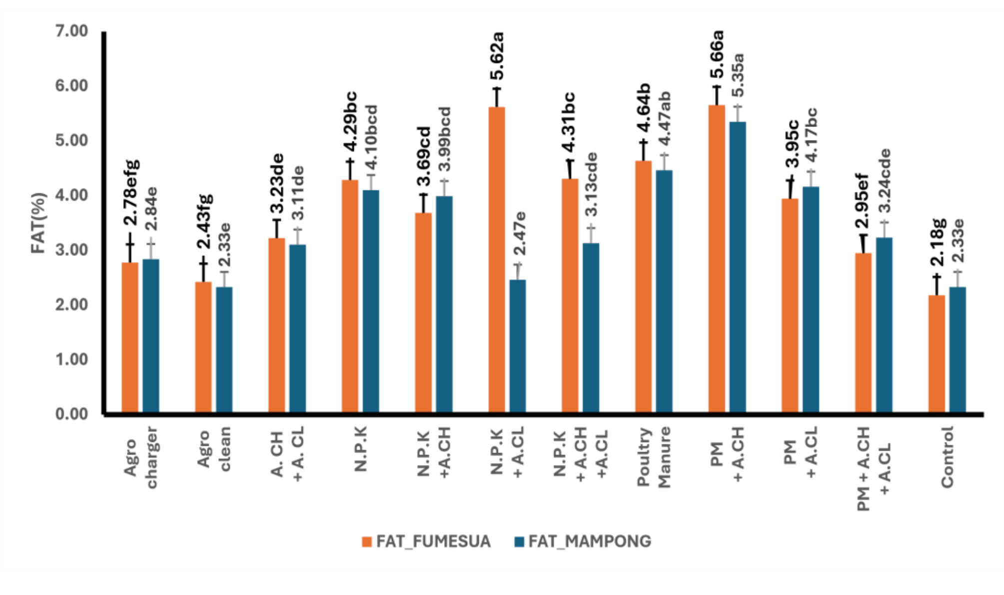

Figure 10: Fat quality (%) of maize (Zea mays L) production Location and Treatments on Total Ash Quality

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The total ash content displayed statistically significant *(P<0.05)* variations between the two sites, with Fumesua recording a higher percentage of 2.48%, while Mampong exhibited a lower value of 2.12% in Figure 11. Similarly, in Figure 12, the combined use of organic crop growth enhancers, inorganic fertilizer, and organic fertilizer significantly influences the total ash content of maize. In this study, NPK + Agro charger + Agro clean and Poultry manure + Agro charger + Agro clean exhibited notably higher ash percentages compared to treatments employing single inputs and the control. Total ash gives a complete appraisal of the total mineral constituency in foods. The biochemical rationale behind these effects lies in the enhanced nutrient dynamics; the inorganic component provides immediate nutrient availability, while the organic inputs improve soil structure and microbial activity, thus fostering a more-efficient nutrient cycling process that increases the concentration of mineral ions in the maize grain. This integrated management approach is supported by various studies, which demonstrated that balanced fertilizer regimes lead to improved nutrient uptake in maize (Annappa et al., 2025; Joshi et al., 2019). Britm and Britm (2025) further confirmed that biostimulants such as "Agro charger" stimulate root growth and subsequent nutrient absorption, thereby elevating the total ash content.

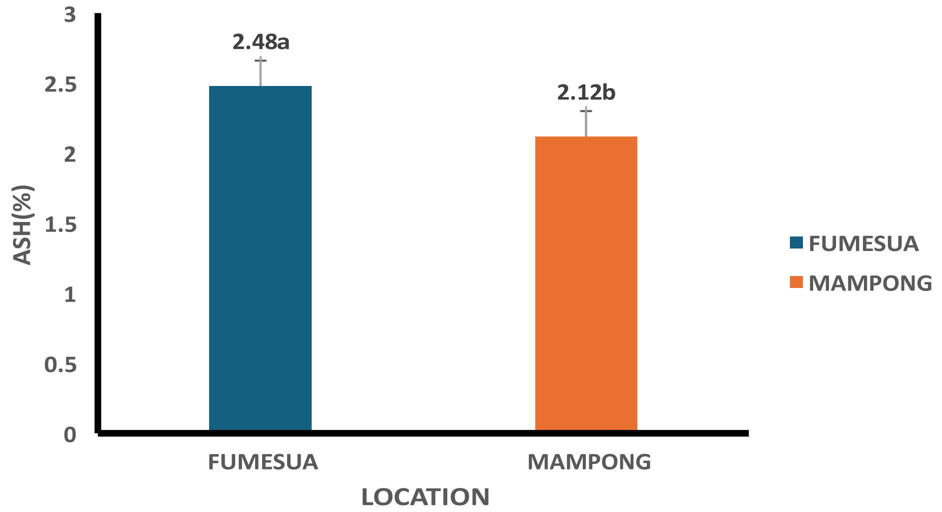

Figure 11: Total ash quality (%) of maize (Zea mays L) production at Mampong and Fumesua

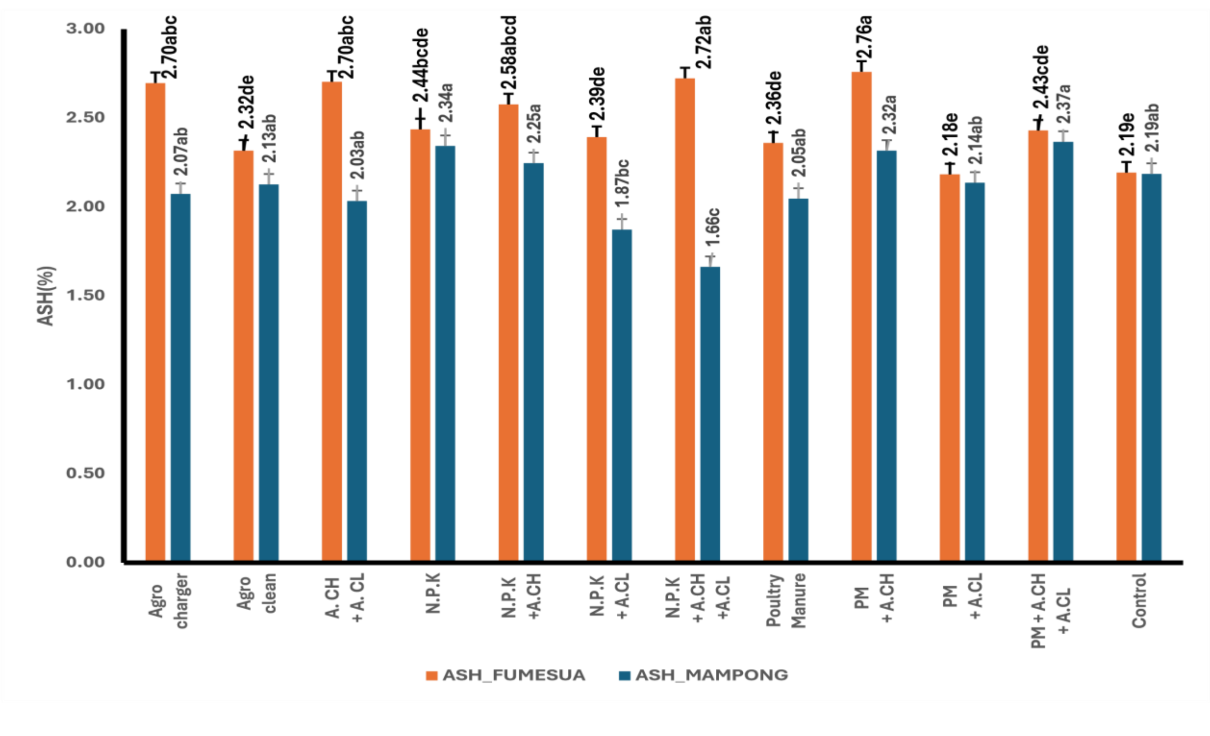

Figure 12: Total ash quality (%) of maize (Zea mays L) production

CONCLUSION

The proximate quality (protein, moisture content, carbohydrate, crude fibre content, fat and total ash) of maize was assessed at Fumesua recorded the best proximate quality compared to Mampong cultivated maize. The Poultry Manure + Agro Charger + Agro Clean treatment produced the highest protein content (16.04% at Mampong and 17% at Fumesua), while NPK + Agro Charger and PM + Agro Charger improved carbohydrate, fibre, fat, and ash levels. Overall, adding Agro Charger or Agro Clean to NPK significantly enhanced maize quality at both locations. Moreover, pertaining to the N.P.K., the individual addition of Agro charger and Agro clean had a significantly positive effect on the proximate quality of cultivated maize at both Fumesua and Mampong.

RECOMMENDATIONS

Based on the findings, the following recommendations were made.

1. It is therefore recommended that farmers prioritizing maize production adopt the integrated use of poultry manure, Agro Charger, and Agro Clean at rates of 5 t/ha + 148 ml per 74 L water/ha + 148 ml per 74 L water/ha (PM + A.CH + A.CL) respectively, to achieve maximum proximate quality.
2. Alternatively, farmers who prefer inorganic fertilizers are advised to apply half the recommended inorganic fertilizer rate alongside Agro Charger at 125 kg/ha + 148 ml per 74 L water/ha (NPK + A.CH) to improve the nutritional value of the maize and profitability.

Author Contributions

E.K.B. responsibly planned, set up, and ran all analyses and wrote the manuscript. H.K.D. provided supervision, editing and reviewing of the manuscript. E.N. was part of the planning, supervision, reviewing and editing, with contributions in the write-up. M.E.E. was part of the supervision team and was involved in reviewing and editing the manuscript.

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For hosting the lead author during research.

Conflicts of Interest

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