

# Effects of Plastic Mulch, Wood-Shaving Mulch, Manual Weeding and Legume Intercropping on Weed Suppression, Rhizosphere Enzyme Activity and Maize (*Zea mays* L) Performance in Buea, Cameroon

Tanting Schneideur Ndongho

[tantingschneideur2017@gmail.com](mailto:tantingschneideur2017@gmail.com)

University of Buea

Lawrence Ndam

University of Buea

Jennifer Engu Chintang

University of Buea

Nelson Che

University of Buea

Loveline Kain Ndosak

University of Buea

Joel Ngemenya

University of Buea

---

## Research Article

**Keywords:** Maize, intercropping, wood shavings, plastic mulch, soil microbial activities, and weed

**Posted Date:** September 16th, 2026

**DOI:** <https://doi.org/10.21203/rs.3.rs-10680901/v1>

**License:**   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

**Additional Declarations:** No competing interests reported.

---

# Abstract

Weed interference and declining soil biological quality constrain rain-fed maize production in humid tropical Cameroon. A randomized complete block experiment with three blocks compared five weed-management systems: untreated weedy control, manual weeding, wood-shaving mulch, maize–legume intercropping and black plastic mulch. Weed biomass, weed density and weed-community attributes were assessed at 4 and 8 weeks after planting (WAP); potential acid phosphatase activity, microbial biomass nitrogen, 1000-grain weight and grain yield were also measured. Intercropping and plastic mulch significantly ( $P < 0.05$ ) reduced weed dry weight and density, whereas the untreated control maintained the highest weed abundance and diversity. Intercropping and wood shaving significantly ( $P < 0.05$ ) enhanced potential soil microbial biomass nitrogen and acid phosphatase activity by 50–75%. Intercropping and plastic mulch significantly ( $P < 0.05$ ) increased 1000 grain weight, but grain yield did not differ significantly ( $P > 0.05$ ). Maize grain yield correlated significantly ( $P < 0.05$ ) with weed dry weight ( $r = -0.68$ ). The results indicate that mulch and legume intercropping can reduce weed pressure in maize; however, inference on soil biological change is limited because microbial indicators were measured at one sampling time without pre-treatment baseline values. Multi-season trials are required before broad recommendations are made.

## 1. Introduction

Maize is the third consume cereal in the world after rice and wheat [1], and many individuals in Cameroon relies on it for their diet [2]. Maize yield in Cameroon is very low, averaging 2.5 tons ha<sup>-1</sup> in small scale cultivation and 4.5 tons ha<sup>-1</sup> in large scale farming [1]. Maize (*Zea mays* L.) is a globally important cereal crop used as human food, animal feed and industrial raw materials [3]. Despite its high yield potential and adaptability, maize productivity is repeatedly limited by both biotic and abiotic challenges [4]. Among the biotic constraints, weed infestation is a major and persistent problem that can cause severe reductions in grain yield by 50% if not managed [5]. This challenge is intensified early in the crop cycle because maize grows relatively slowly during seedling establishment, making it highly vulnerable to competition for light, soil moisture, and nutrients [6].

Traditional weed control method, particularly labor-intensive manual hand-weeding, is becoming less feasible because of increasing labor cost and shortages [7]. At the same time, heavy reliance on chemical herbicides raises long-term concerns such as herbicide-resistant weed biotypes, soil degradation, and herbicide runoff into water systems [8]. These issues motivate the search for more sustainable and ecologically sound cultural weed management approaches [9].

Mulching has been identified as an effective environment-friendly weed management practice capable of substituting for herbicides to a significant extent [10]. By covering the soil surface, mulching act as a barrier that reduces light penetration required for weed seed germination and early growth. Additionally, mulch helps conserve soil moisture, reduces temperature fluctuations, and supports better seedling

establishment and survival by lowering direct exposure of the soil to solar radiation [11]. However, the effectiveness of mulching depends strongly on the type of mulch used [12].

Because synthetic and organic mulches differ in physical behavior and soil effects, they can produce different outcomes for maize growth and yield. Plastic mulch may increase early-season growth by trapping heat and improve soil fertility [13]. Organic mulches will improve soil microbial properties such as acid phosphatase and microbial biomass nitrogen through decomposition of soil organic matters and nutrient release [14]. Intercropping maize with groundnut can be another valuable alternative as they will be competition for light, nutrients and space between the weeds and groundnut leading to reduce weed infestations [15], increase in acid phosphatase and microbial biomass nitrogen [16]. This study evaluated the effects of five weed-management systems on weed biomass, weed density, weed-community attributes, potential acid phosphatase activity, microbial biomass nitrogen, 1000-grain weight and grain yield in rain-fed maize. We hypothesized that: (i) weed-management system affects weed biomass, density and community diversity; (ii) weed-management system affects potential acid phosphatase activity and microbial biomass nitrogen; and (iii) weed-management system affects maize grain yield and 1000-grain weight.

## **2. Materials and Methods**

### **2.1 Experimental site and design**

The field experiment was conducted from April to June 2026 at Chief Street, Bomaka, Buea, Cameroon (latitude 4.1578°N, longitude 9.3164°E, elevation of 494508 m). The site lies within Cameroon's humid forest agroecological zone (Zone IV). Field experiment was established in a randomized complete block design. The field was divided into three blocks with each block representing a replicate and each experimental unit measured 4m x4m. The inter-block spacing was 1m while the distance in between two plots was 1 m with a border of 1m round the plot used. The entire 288 m<sup>2</sup> experimental field was cleared, raked and laid out using a measuring tape, ropes and a stick to mark the various plots for easy identification during ploughing.

### **2.2. Field preparation**

#### **2.2.1 Treatments application**

A total of 5 treatments were used to investigate the effect of weed management methods on weed infestation, soil microbial activities and maize yield in the various plots. These treatments were control, weeding, wood shaving, intercropping, and plastic mulch (Table 1). Each of the above treatments were randomized on 3 different plots within the various blocks. For the control plot, they were no application of weed control method, for the weeding plot, weed sampling at 4 WAP was conducted before the scheduled manual-weeding operation. Weed sampling at 8 WAP was conducted before the second weeding operation. Therefore, weed data at each time point represent pre-weeding weed pressure.

Groundnut (*Vigna subterranean*) was planted at the intercrop plot. Air-dried, untreated wood shavings from Eucalyptus (*Tectona grandis*) were applied uniformly at 15 tons dry matter ha<sup>-1</sup>, corresponding to an average depth of 2 cm. Shavings were visually screened to exclude painted, glued, treated or contaminated materials. Black polyethylene mulch of 100–120 µm thickness was applied to cover the plot surface; circular planting holes of 10–15 cm diameter were made at each maize planting station.

Table 1  
Treatments of the experiment and  
their description

| Treatments | Description    |
|------------|----------------|
| T 1        | Control        |
| T 2        | Manual weeding |
| T3         | Plastic mulch  |
| T4         | Intercropping  |
| T5         | Wood shaving   |

Table 2  
Effects of weed management methods on weed diversity

| Week after planting (WAP)                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Treatment     | Weed abundance (N) | Species richness (S) | Shannon–Wiener (H') | Simpson diversity (1 – D) | Pielou evenness (J') |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|--------------------|----------------------|---------------------|---------------------------|----------------------|
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Control       | 21.33              | 5.00                 | 1.57                | 0.78                      | 0.98                 |
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Weeding       | 18.33              | 5.67                 | 1.65                | 0.79                      | 0.97                 |
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Intercrop     | 7.00               | 4.67                 | 1.37                | 0.70                      | 0.97                 |
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Wood shaving  | 6.33               | 3.33                 | 1.14                | 0.66                      | 0.96                 |
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Plastic mulch | 0.00               | 0.00                 | non-estimable       | non-estimable             | non-estimable        |
| 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Control       | 15.67              | 4.33                 | 1.44                | 0.76                      | 0.98                 |
| 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Wood shaving  | 11.67              | 4.00                 | 1.32                | 0.72                      | 0.97                 |
| 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Weeding       | 5.00               | 2.33                 | 0.78                | 0.51                      | 0.93                 |
| 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Intercrop     | 0.00               | 0.00                 | non-estimable       | non-estimable             | non-estimable        |
| 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Plastic mulch | 0.00               | 0.00                 | non-estimable       | non-estimable             | non-estimable        |
| <p>Species richness (S) is the number of spontaneous weed species per plot. Shannon diversity was calculated as <math>H' = - \sum p_i \ln p_i</math>; Simpson diversity was calculated as <math>1 - D = 1 - \sum p_i^2</math>; and Pielou evenness was calculated only for plots with <math>S &gt; 1</math>. For plots in which no weeds were recorded, abundance and richness were reported as zero, whereas diversity and evenness were recorded as not estimable (NA)</p> |               |                    |                      |                     |                           |                      |

## 2.2.2. Planting and field maintenance

Maize(CMS8704) and groundnut (Bambara) seeds were gotten from Agricultural Research Institute for Development (IRAD), Foubot. After the different treatments were applied on the various plots, the planting distance of maize (CMS8704) was mapped out using a measuring tape that is, an inter-row spacing of 50 cm and inter-column spacing of 75 cm was used (50 cm x 75 cm) at about 2–3cm depth, with 3 seeds per stand. These were thinned to two vigorous plants per stand at 2 weeks after sowing. This gave a total of 84 plants per 4x4 m plot and extrapolated to 53,333 plants per hectare. This distance was applicable in all the plots in the field, while living mulch (groundnut) was planted with a distance of 25cm x 25cm, and about 2–3cm depth. This gave a total of 256 plants per plot, and extrapolated to 160,000 plants per hectare. The field was bordered with mosquito nets around the land to avoid pest

infestations (ducks, rats, and man) and direct entry to the research site. Mulching was done for each stand to assist the plant for easy anchorage in order resist wind from blowing them to the ground. Soil moisture content during the entire experiment for both cropping seasons relied solely on rainfall pattern of the study site.

## 2.3. Data collection

### 2.3.1. Weed dry weight, density and diversity

Before the data was collected for weed diversity, a quadrat was made within the plot with a distance of 1m x 1m and the weed within the different quadrat were collected. This was to identify the different types of weed found in various plots of each block. Weed diversity was collected at 4 weeks after planting and 8 weeks after planting and weed species per plot determined using the plant net app. The weed fresh weight was weighed using a weighing balance and oven dry at 60°C for three days at the Life Science Laboratory, Faculty of Science University of Buea. For weed diversity, Initial image-based identifications were verified using regional floras and authenticated herbarium material. Scientific names and authorities were standardised using Plants of the World Online

Weed density was calculated using the formula below [17].

$$\text{Weed density} = \frac{\text{Number of weed in the quadrat}}{\text{Area of quadrat}} \dots\dots\dots(1)$$

### 2.3.2. Soil microbial activities and maize yield

Five maize plants were randomly selected at the tasselling stage (8 weeks after planting) and tagged for collection of rhizosphere soil sample to analyse for acid phosphatase and microbial biomass nitrogen. A spade was used to dig 5 cm around each plant at a depth of 20 cm. Secondary roots adhering to the soil were excised, and the soil was bulked to form a composite sample. Adhering soil (5 g) was collected from each of the four replicates per treatment, and bulked to form a composite sample of 20 g. This was performed for all the 5 treatments and 3 replicates. Samples were analyzed at the University of Yaounde 1, Cameroon, to measure potential microbial activities. Soil microbial biomass nitrogen was determined by fumigation extraction method [19], and acid phosphatase by P-nitrophenyl phosphate (p-NPP) method [18].

Maize grain yield was collected by manually harvesting 10 randomly selected and tagged plants per plot at full maturity at the R6 stage, 3 months after planting. Harvested maize was hand-threshed and oven-dried at 60°C for three days to 10% moisture content-determined using a moisture meter (Kett PM-650, Japan). Dry maize grains were weighed on a scale balance, and the yield extrapolated to tons ha<sup>-1</sup> for each treatment. 1000 maize grain weight was determined for each treatment using a weighing balance.

## 2.4. Statistical analysis

Data set were subjected to statistical analyses using Statistical Package for Social Science (SPSS). Data sets were checked for normality and homogeneity using Kolmogorov-Smirnov and Lilliefors tests, respectively. For weed managements effects, univariate analysis of variance (ANOVA,  $P < 0.05$ ) was conducted significant different mean were compared by Post hoc Tukey's HSD test ( $P < 0.05$ ). This analysis was also conducted for maize yield, 1000 grain weight, microbial biomass nitrogen, acid phosphatase activity, weed dry weight and weed density. Independent T-test was conducted across week 4 and week 8 for each weed management method to determine the effects of weeks on weed dry weight and weed density. The weed abundance data were used to calculate the following indices: Species richness(S): Total number of weed species recorded per treatment, Shannon-Wiener diversity index(H), Simpsons diversity index(1-D) and Pielous evenness index(J)

### 3. Results

#### 3.1. Effects of weed management methods on weed dry weight.

At 4 weeks after planting, weed dry weight (WDW) significantly differed across weed management methods ( $P < 0.05$ ; Fig. 1) and ranged from 0-58.3g. Weeding recorded the highest weed dry weight (58.3g), followed by wood shaving (33.5g), while the control measured 24.2 g, with intercrop measuring 6.2g and plastic mulch measured 0g (Fig. 1). At 8 weeks after planting, weed dry weight significantly differed across treatments ( $P < 0.05$ ; Fig. 1), weed dry weight had declined across all treatments and ranged from 0-9.7g. Wood shaving measured the highest weed dry weight (9.7g), weeding measured 5.6 g, with the control measuring 2.7g, Intercropping and plastic mulch measured 0 g (Fig. 1).

Across weeks for each treatment, they were significant differences ( $P < 0.05$ ; Fig. 1) between the control, weeding, intercrop and wood shaving with the highest weed dry weight occurring at 4 weeks after planting (Fig. 1). Intercropping measured weed dry weight of 6g at 4 weeks after planting and measured 0 g at 8 weeks after planting. Weeding recorded the highest weed dry weight at 4 weeks after planting (57g) and measured 5.3 g at 8 weeks after planting. Wood shaving measured 71g at 4 weeks after planting and 8g at 8 weeks after planting. The control measured weed dry weight of 25 g at 4 weeks after planting and 5 g at 8 weeks after planting (Fig. 1)

#### 3.2. Effects of weed management methods on weed density.

At 4 weeks after planting, weed density significantly differed across treatments ( $P < 0.05$ ; Fig. 2) and ranged from 0-6.6. Weeding recorded the highest weed density (6.6), followed by intercrop and control (5.0), while wood shaving measured 3.3, and plastic mulch had the lowest (0). At 8 weeks after planting, weed density significantly differed across treatments ( $P < 0.05$ ; Fig. 2) and ranged from 0-4.3. Control measured the highest weed density (4.3), followed by wood shaving (3.6), while weeding measured 2.3, plastic mulch and intercrop had the lowest (0).

Across weeks for each treatment, they were a significant difference ( $P < 0.05$ ) between the weeding and intercrop with the highest weed density occurring at 4 weeks after planting (Fig. 2). Weeding measured weed density of 6.6 at 4 weeks after planting and measured 2.6 at weeks 8 after planting. Meanwhile the intercrop measured 5.0 at 4 weeks after planting and measured 0 at weeks 8 after planting (Fig. 2)

### 3.3. Effects of weed management methods on weed diversity

At 4 weeks after planting, the control had the highest mean weed abundance (21.33 weeds per sampling unit), whereas the weeding treatment had the highest mean species richness (5.67 species) and Shannon diversity ( $H' = 1.647$ ). Plastic mulch completely suppressed the recorded weed community, giving zero abundance, richness, and diversity. At 8 weeks after planting, weed abundance and diversity had changed considerably. The control maintained the greatest abundance (15.67) and highest Shannon diversity ( $H' = 1.437$ ), followed by wood shaving. The intercrop and plastic mulch treatments recorded no weeds at 8 weeks after planting in the supplied dataset. This indicates strong weed suppression under those treatments at that sampling time. The treatment effect was statistically significant for the main weed-community variables, including total abundance, species richness, Shannon diversity and Simpson diversity at both sampling periods. For example, abundance differed significantly among treatments at 4 WAP ( $F = 12.31$ ,  $p = 0.0007$ ) and even more strongly at 8 weeks after planting ( $F = 111.08$ ,  $p < 0.001$ )

### 3.4. Weed species identified across different weed management methods in the maize production farm

From the result of this study, at 4 weeks after planting, a total of 33 weed species was identified; *Cleome rutidosperma* and *Corchorus olitorius* were the most frequent (5 each, 8.3%). *Cyathula prostrata*, *Jatropha curcas*, and *Calopogonium mucunoides* followed as moderately frequent (3 each, 5.0%). *Vigna luteola*, *Asystosia gangetic*, *Cleome viscosa*, *Manihot esculenta*, *Amarathus viridis*, *Colocasia esculenta*, *Senna alatata* and *Commolina communis* followed (2 each, 3.3%). *Hibiscus laevi*, *Carica papaya*, *Eleusine indica*, *Ipomaea batatas*, *Grome trifila*, *Abelmoschus esculentus*, *Amaranthus blitum*, *Commelina diffusa*, *Persicon pensylvania*, *Chamoecrista rotundifolia*, *Acmella pilosu*, *Ageratum conyzoides*, *Cyperus rutundus*, *Euphorbia opthalmica*, *Calopogonium mucunoides*, *Emilia sonchifolia*, *Poa annua*, *Persicaria virginianu*, *Fatoua villusa* and *Amacanptis pyramidis* followed (1 each, 1.7%).

By 8 weeks after planting, 13 weed species was identified; *Cleome rutidosperma* remained the most frequent species (6, 16.2%). Followed by *Ageratum conyzoides* (5, 13.2%), *Dicliptera brachiata* followed (4, 10.5%). *Calopogonium mucunoides* followed (3, 7.9%), *Corchorus olitoris*, *Cyperus rutundus*, *Caloponium mucunoides*, *Commelina communis* (2, 5.3%). *Jatropha curcas*, *Commolina communis*, *Kaemoptera galangu*, *Laporatea aestuans*, *Alternathera sessilis* (1, 2.6%).

### 3.4. Effects of weed management methods on potential soil microbial activities

Potential acid phosphatase activities significantly ( $P < 0.05$ ; Fig. 3A) differed across treatments. The value ranged from 0.2–1.4 mmol kg<sup>-1</sup> h<sup>-1</sup> with the highest in the intercrop (1.4 mmol kg<sup>-1</sup> h<sup>-1</sup>), jointly followed by wood shaving and weeding (0.6 mmol kg<sup>-1</sup> h<sup>-1</sup>), plastic mulch measured 0.55 mmol kg<sup>-1</sup> h<sup>-1</sup> and the lowest in the control (0.2 mmol kg<sup>-1</sup> h<sup>-1</sup>). Intercropping significantly increased potential soil acid phosphatase activities by 75% when compared to the control, and wood shaving and weeding increased potential acid phosphatase by 50% when compared to the control (Fig. 3A). Potential microbial biomass nitrogen significantly ( $P < 0.05$ ; Fig. 3B) differed across treatments. The value ranged from 170–1200 mb mg kg<sup>-1</sup> soil with the highest in the intercrop 1200 mb mg kg<sup>-1</sup>, followed by wood shaving 810 mb mg kg<sup>-1</sup>, the control measured 150 mb mg kg<sup>-1</sup>, with the lowest in weeding and plastic mulch measuring 50 mb mg kg<sup>-1</sup>. Intercropping and wood shaving increased potential soil microbial biomass nitrogen by 75.1% and 67.3% respectively when compared to the control (Fig. 3B)

### 3.5. Effects of weed managements methods on maize 1000 grain weight and yield

Maize 1000 grain weight significantly ( $P < 0.05$ ; Fig. 4A) differed across treatments. The value ranged from 230–380 g with the highest in the intercrop plot (380 g), followed by plastic sheet (360g), weeding measured 325g, and with the lowest in the control and wood shaving (230g). Intercropping and plastic mulch increased 1000 grain by 24.5% and 22% respectively when compared to the control.

Maize grain yield didn't differ significantly( $P > 0.05$ ; Fig. 4B) across treatments. The value ranged from 2.3-5 tons ha<sup>-1</sup>. Even though they were no statistically significant differences of maize yield across treatments, intercropping numerically had the highest maize yield (5 tons ha<sup>-1</sup>), followed by plastic sheet (4.5 tons ha<sup>-1</sup>), weeding, control and wood shaving measured 4.2 tons ha<sup>-1</sup>, 2.3 tons ha<sup>-1</sup> and 1.9 tons ha<sup>-1</sup> respectively. Maize grain yield correlated significantly ( $P < 0.05$ , Table 3) with weed dry weight ( $r = -0.68$ ).

Table 3  
Correlation of maize grain yield with acid phosphatase, microbial biomass nitrogen, weed density and weed dry weight

| Variables                  | Grain yield       |
|----------------------------|-------------------|
|                            | <i>r</i> - values |
| Weed density               | -0.25             |
| Acid phosphatase           | 0.44              |
| Microbial biomass nitrogen | 0.28              |
| Weed dry weight            | -0.68*            |

## 4. Discussion

### 4.1. Effects of weed management methods on weed infestation and maize performance

The lower weed dry weight and density observed under plastic mulch is consistent with physical exclusion of light and the emergence barrier created by an opaque mulch. The lower weed pressure under the maize–legume system may reflect increased ground cover and resource capture. Because soil light environment, moisture, temperature, canopy cover, nitrogen transfer and weed emergence were not measured, the relative contribution of these mechanisms cannot be determined in the present study [20]. The reduction in weed dry weight in the wood shaving treatment at fourth week after planting could be due to the fact that wood shaving acted as a mulch layer effectively suppressing weed growth by blocking sunlight and physical weed emergence leading to a significant reduction in weed density and weed dry weight when compared to the control [21]. The reduction of weed dry weight and weed density in maize-groundnut intercrop treatment could be due to the fact that groundnut quickly covers the soil and prevent weeds from germinating and establishing on the soil surface [22]. They was high weed dry weight, density and diversity in week 4 after planting when compared to week 8 across weed management methods, this could be due to the fact that at week 8, maize plant grows large and blocks the sun, and the soil space becomes crowded leading to decrease in weed density, dry weight and diversity, on the other hand, at week 4, maize plant is young, small and soft, they weight very little, thus making it possible for the weed to grow leading to increase in weed density, dry weight and diversity [23]. A total of 33 and 13 weed species were observed at week 4 and 8 respectively, which therefore support our hypothesis that different weed species will infest the maize field, which therefore support our hypothesis that weed-management system affects weed biomass, density and community diversity. The negative correlation between weed dry weight and maize yield could be due to the fact that as weed biomass increases due to competition for light, water, and space between maize and weed [24]. The increase in 1000 grain weight in the intercrop and plastic sheet treatments could be due to the fact that plastic sheet retain the soil moisture and increase temperature, meanwhile intercropping with groundnut improves nitrogen availability, boosting kernel filling and grain weight, these individual mechanisms lead to increase in 1000 grain weight in these treatments more than the control [25], which support our hypothesis that weed-management system affects maize grain yield and 1000-grain weight.

## 2. Effects of weed management methods on potential soil microbial activities

Potential microbial biomass nitrogen and acid phosphatase activities in crop rhizosphere are highly affected by farm management practices [26]. Soil enzymes activity such as acid phosphatase serves as key indicator of soil fertility, soil quality and soil health [27], which arise from a combination of crop root secretion and the stimulation of soil microorganisms, which play crucial role in the decomposition of organic matter and phosphorus cycling [28]. High acid phosphatase activity for intercrop than the control

is probably due to additional effects of groundnut in exuding more protons, acid phosphatase and carboxylates, which increased concentration of soil organic phosphorus [29, 30]. The increase in acid phosphatase activity in the plastic mulch treatment more than the control could be due to the fact that plastic mulch blocks evaporation and microorganisms need water to grow and produce enzymes, thus more moisture lead to more microbial activity leading to more acid phosphatase activity [31]. Higher acid phosphatase activity in the wood shaving treatment more than the control could be due to the decomposition of the wood shaving with the aid of microorganisms which help break down the Carbon rich material during this process they need phosphorus and to get it, more acid phosphatase is release to mineralize organic P [32]. More acid phosphatase activity in the weeding treatment more than the control could be due to the fact that when weed are remove, the maize root grow better and release more root exudates, these exudates stimulate the microbes that produce acid phosphatase [33]. Increase in microbial biomass nitrogen in maize-groundnut intercropping plot more than the control is likely due to additional effects of groundnut in secreting more organic compounds in maize rhizosphere, leading to enhanced carbon source and microbial growth [30, 34–36]. Higher microbial biomass nitrogen in the wood shaving treatment more than the control could be due to decomposition of the wood shavings which gives microbes lots of carbon, and for these microbes to use the carbon, nitrogen is needed, thus nitrogen is immobilize into their biomass, thus leading to higher microbial biomass nitrogen [37]. More microbial biomass nitrogen in the control more than the weeding and plastic mulch treatments is likely due to the fact that in the control, the weed grows, die and decompose leading to increase in soil microbial nitrogen [38]. This finding therefore support our hypothesis that weed-management system affects potential acid phosphatase activity and microbial biomass nitrogen.

## 5. Conclusion

This study demonstrated that conservation practices including groundnut intercropping, plastic mulch and wood shavings significantly improved soil biological quality and weed suppression in maize farming system in Cameroon. Most of these practices increased soil microbial biomass nitrogen and acid phosphatase activity compared to the weeded control, indicating enhanced N cycling and P mineralisation potential. Concurrently, plastic mulch, wood shavings and intercropping reduced weed dry weight and weed density, thereby reducing crop weed competition. These findings suggest that integrating mulches and groundnut intercrop with maize can simultaneously address weed management and soil fertility constraints faced by small holder farmers in sub-Saharan Africa, offering a viable pathway toward sustainable intensification. Future research should quantify the long term effects of these practices on maize grain yield and soil carbon sequestration across multiple seasons.

## Declarations

## Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported on this paper.

### **Ethics approval**

The maize plant used in this study were cultivated under standard national and international guidelines on agricultural practices and sampled within acceptable agronomic limits on cultivated crops.

### **Consent to participate**

Maize is economically important, environmentally friendly not threatened by extinction. Therefore, no specific permission or licenses were required for collecting maize plant part.

### **Consent to publish**

Not applicable

## **Funding**

This study did not receive any external funding.

## **Author Contribution**

All authors contributed to the study concept. Material preparations, data collections and analyses were performed by Schneideur Ndongho Tanting, Jennifer Engu Chintang, Nelson Che, Loveline Kain and Joel Ngemenya. Supervision was done by Schneideur Ndongho Tanting, and Lawrence Ndam. The first draft of the manuscript was written by Schneideur Ndongho Tanting and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

## **Acknowledgements**

We acknowledge Veracity Higher Institute of Business, Biomedical Sciences and Technology for providing us with the land we used for this study. We acknowledge the Life science laboratory, Faculty of Science, University of Buea for providing us with an oven for this experiment.

## **Data availability statement**

All data generated or analysed during this study are included in this published article

## **References**

1. FAOSTAT (2021). FAOSTAT. FAO, Rome. <http://www.fao.org/faostat>.
2. Jansen L, Undorf S, Gornott C. (2025). Current and future adaptation potential of heat tolerant maize in Cameroon: a combined attribution and adaptation study. *Environ Res Lett* 20(2). <https://doi.org/10.1088/1748-9326/ada459>
3. Tiah, F.S., Msuya, D.G., Nassary, E.K., Tryphone, G.M. (2026). Maize seed quality attributes: Exploring genetic, agronomic, and environmental factors for sustainable improvement-A systemic review. *Journal of Agriculture and Food Research* 25 <https://doi.org/10.1016/j.jafri.2025.102623>
4. Pannaree, B., Ariya, G., Jonathan, D. P., Cole, J. (2026). Fall armyworm infestation and future likelihood of spread due to environmental change in maize-cropping regions in Kenya. CABI Agriculture and Bioscience. <https://doi.org/10.1079/ab.2026.0007>
5. Soltani, N., Dille, J.A., Burke, I. C., Everman, W.J., VanGessel, M.J., Davis, V.M., Sikkema, P.H. (2016). Potential corn yield losses from weeds in North America. *Weed Technol*, **30**, 979-984
6. Goranovska, S., Kalinova, S.Yanev, M.(2022).Influence of herbicides and foliar fertilizers on the yield and the structural elements of yield and technological qualities of the maize gr
7. Xuan, D. J., Khanh, J. D., Minh, T. T. N. M. (2025). Implementation of conventional and smart weed managements strategies in sustainable agricultural production. *Weed Bio and Manage* **25**(1), <https://doi.org/10.1111/wbm.70000>
8. Kaur, S., Mendes, K. F., Ekeleme, F., Chachalis, D., Chauhan, B.S. (2024). Editorial: Herbicide efficacy. *Frontiers in Agronomy* **6**(1). <https://doi.org/10.3389/fagro.2024.1504465>
9. Monteiro, A., Santos, S. (2022). Sustainable approach to weed management: The role of precision weed management. *Agronomy* **12**(1), <https://doi.org/10.3390/agronomy12010118>
10. Sosna, I., Fudali, E. (2024). Living mulches in-rows as an alternative for herbicide fallow in a pear *Pyrus communis* L. orchard. *Horticultural Science*
11. Rehman, O., Rizvi, S. A., Khan, M., Aulakh, A.M., Yunas, M., Hussain, T., Naseem, W., Bibi, R., Malik, S.N., Majeed, M.D. (2025). Mulching technology for moisture conservation: Strategies and applications for Rainfed Area. *Planta Animalia* **4**(2):179-195. <https://doi.org/10.71454/004.02.0129>
12. Dragumilo, A., Markovic, T., Vrbnicanin, S., Gordanic, S., Lukic, M., Rajkovic M., Prijic, Z., Bozic, D. (2025). Mulching for weed management in medicinal and aromatic cropping systems. *Horticulturae* **11**(9). <https://doi.org/10.3390/horticulturae11090998>
13. Hofmann, T., Ghoshal, S., Tufenkji, N., Adanowskim, J.F., Bayen, S., Chen, Q., Demokritou, P.et al. (2023). Plastic can be used more sustainably in agriculture. *Communications Earth and Environment* 4(1), <https://doi.org/10.1038/s43247-023-00982-4>
14. Sun, X., Ye, Y., Liao, J., Soromotin, A.V., Smirnov, P.V., Kuzyakov, Y. (2022). Organic mulching increases microbial activity in Urban Forest soil. *Forests*,**13** (9),1352. <https://doi.org/10.3390/f13091352>
15. Eni, E., Olusegun, R. A., Segun, T. O.L., Osebekwin, E. A. (2021). Enhancing the weed control efficacy of two pre-emergence herbicides in maize/groundnut intercrops in derived savanna. *Journal of Agricultural Sciences* 66(4), <https://doi.org/10.2298/JAS2104335E>

16. Liu, P. F., Zhao, Y.K., Ma, J. N. et al. (2025). Impact of various intercropping modes on soil quality, microbial communities, yield and quality of *Platycodon grandiflorum*(Jacq). *Plant Biol* 25,503. <https://doi.org/10.1186/s12870-025-06544>
17. Guncan, A. (2014). Weeds and principles, Selcuk Univ. Agriculture Faculty, Textbook, Konya,309.
18. Bradford MM (1976) A rapid and sensitive method for the quantification of microgram quantities of protein utilizing the principle of protein dye binding. *Anal Biochem* 72(1), 248-254.
19. Vance ED, Brookes PC, Jenkinson DS (1987) An extraction method for measuring soil microbial biomass. *Soil Bio Biochem* 19:703-707.[https://doi.org/10.1016/0038-0717\(87\)90052-6](https://doi.org/10.1016/0038-0717(87)90052-6)
20. Mehmood, T., Khan, S.U., Qayyum, A., Gurmani, A.R., Ahmed, W., Liaquat, M., Fariq, A. (2018). Evaluation of organic and inorganic mulching as an integrated weed management strategy in maize under rain feed conditions. *Planta Daninha* **36**, e018184892. <https://doi.org/10.1590/S0100-83582018360100143>
21. Bozhuyuk, A.U., Gurbuz, R., Alptekin, H., Kayci, H. (2022). The use of different waste mulch materials against weeds which are problems in tomato (*Solanum lycopersicum* L) cultivation. *Selcuk Journal of Agricultural and Food Sciences*. <https://doi.org/10.15316/SJAFS.2022.029>.
22. Gue, A., Sylla, M., Koulibaly, A.V., Karidia, T.O. (2025). Influence of maize (*Zea mays* L) and Cowpea (*Vigna unguiculata*) intercropping on weed growth and maize yield in Daloa. *Scholars Academic Journal of Biosciences*. <https://doi.org/10.36347/sajb.2025.v13i12.010>
23. Horvarth, D.P., Clay, S. A., Swanton, C.J., Anderson, J.V., Chao, W.S. (2023). Weed-induced crop yield loss: A new paradigm and a new challenge. *Trends Plant Sci* **28**,567-582
24. Garko, M.S., Dawaki, D.K. Yawale, M. A., Mohammed, I. B., Yaroson, A. Y. (2020). Correlations among grain yield, yield and weed attributes of maize (*Zea mays* L) as influenced by weed control method and poultry manure rate in Kanu state Nigeria. *International Journal of Research-Granthaalayah* **8**(4). <https://doi.org/10.29121/granthaalayah.v8.i4.2020.15>
25. Talebbeigi, R.M., Ghadiri, H. (2012). Effects of cowpea living mulch on weed control and maize yield. *Journal of Biological and Environmental Sciences* **6**:189-193
26. Kaushal M, Kolombia Y, Alakonya AE, Kuate AF, Alejandro OB, Amah D, Massa C (2021) Subterranean microbiome affiliations of plantain (*Musa spp*) under diverse agro ecologies of Western and Central Africa. *Microb Ecol* 84(2) pp 580-593.
27. Juan, L; Zhao, B. Q; Li, X. Y., Jiang, R. B; Bing, S. H. (2008). Effects of long term combined application of organic and mineral fertilizers on microbial biomass, soil enzyme activities and soil fertility. *Agric. Sci. China* **7**,336-343
28. Luo, L., Meng, H., Gu, J.D. (2017). Microbial extracellular enzymes in biogeochemical cycling of ecosystems. *J. Environ. Manag* **197**,539-549
29. Litati M, Blavet D, Alkama N, Laoufi H (2014) The intercropping of cowpea-maize improves soil phosphorus availability and maize yields in an alkaline soil. *Plant Soil* 385(1-2),181-191.
30. Tanting, S.N., Enyoe, M. N.O., Ndzeshala, S.T., Achiri, D.T., Ngone, M.A., Tening, A.S., Ruppel, S., Ngosong, C. (2026). Beneficial microbes, plant extracts and cropping systems enhance maize yield

- and land use efficiency via rhizosphere microbial biomass nitrogen, acid phosphatase and urease activities. *Discover Agriculture* 4(254). <https://doi.org/10.1007/s44279-026-00720-2>
31. Munoz, K., Bruhn, S.T., Kenngott, K.G.J., Meyer, M., Diehl, D., Steinmetz, Z., Schaumann, G.E. (2022). Effects of plastic versus straw mulching on soil microbial community structure and enzymes in strawberry cultivation. *Soil systems*. <https://doi.org/10.3390/soilsystems6010021>
  32. Ji, X.Y., Xu, Q., Zhao, Z.Q., Zheng, Y.X., Deng, L., Hu, Z.H. (2023). Influences of wood decomposition associated with tree types on soil nutrient concentrations and enzyme activities. *Forests*. <https://doi.org/10.3390/f14091846>
  33. Kalyani, M.S.R., Ameen, M., Pillai, P.S., Sheeja, K.R., Susha, V.S., Sreelakshmi, K., Joy, M., Anith, K.N. (2025). Soil biological health under integrated weed management strategies in grain cowpea (*Vigna unguiculata* (L) walp). *Plant Science Today* **13**. <https://doi.org/10.14719/13466>
  34. Lai H, Gao F, Su H, Zheng P, Li Y, Yao H (2022) Nitrogen distribution and soil microbial community characteristics in a legume-cereal intercropping system: A review. *Agron* 12(8).
  35. Silva L, Vieira J, Laroca S, Coelho AP, Gonçalves EC, Gomes RP, Pacheco LP, Caesar PM, Carvalho PC, Oliveira RF, De Souza JMA, Frieta CM, Cabral CE, Wruck J, de Souza ED (2022). Does grass-legume intercrop change soil quality and grain yield in integrated crop-livestock systems? *Appl Soil Ecol* 170:104257.
  36. Nascimento G, Cantero MC, Jorge AV, Lafuente V, Villegas D (2025) Benefits of a ceding legume crop for soil organic matter and microbial dynamics during wheat residue decomposition. *Soil Use Manage* 41: e70116. <https://doi.org/10.1111/sum.70116>
  37. Clochiatti, A., Hannula, S.E., Maria, P.J.H., Gunnewiek, P.J.A.K., Boer, W. (2023). Utilizing woody materials for fungal-based management of soil nitrogen pools. *Applied Soil Ecology* 181. <https://doi.org/10.1016/j.apsoil.2022.104663>
  38. Baaru, M., Mungendi, D.N., Bationo, A., Verchot, L. (2007). Soil microbial biomass carbon and nitrogen as influenced by organic and inorganic inputs at Kabete, Kenya. *Advances in Integrated Soil Fertility Management in sub-Saharan Africa: Challenges and Opportunities* 827-832. <https://doi.org/10.1007/978-4020-5760-1-78>

## Figures

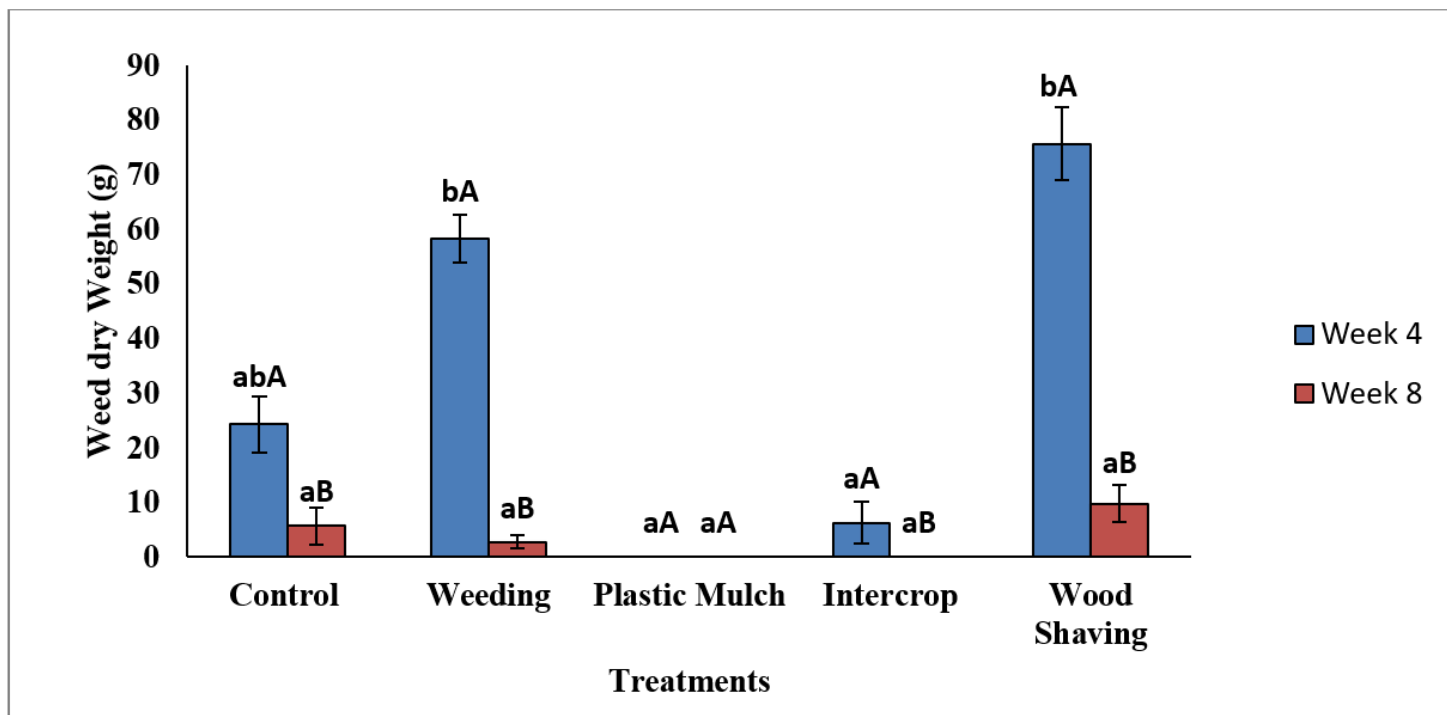


Figure 1

Weed dry weight at 4 and 8 weeks after planting. Bars with different lowercase letters indicate significant differences among treatments within the same week, while different uppercase letters indicate significant differences between weeks within the same treatment (Tukey's HSD test,  $P < 0.05$ ).

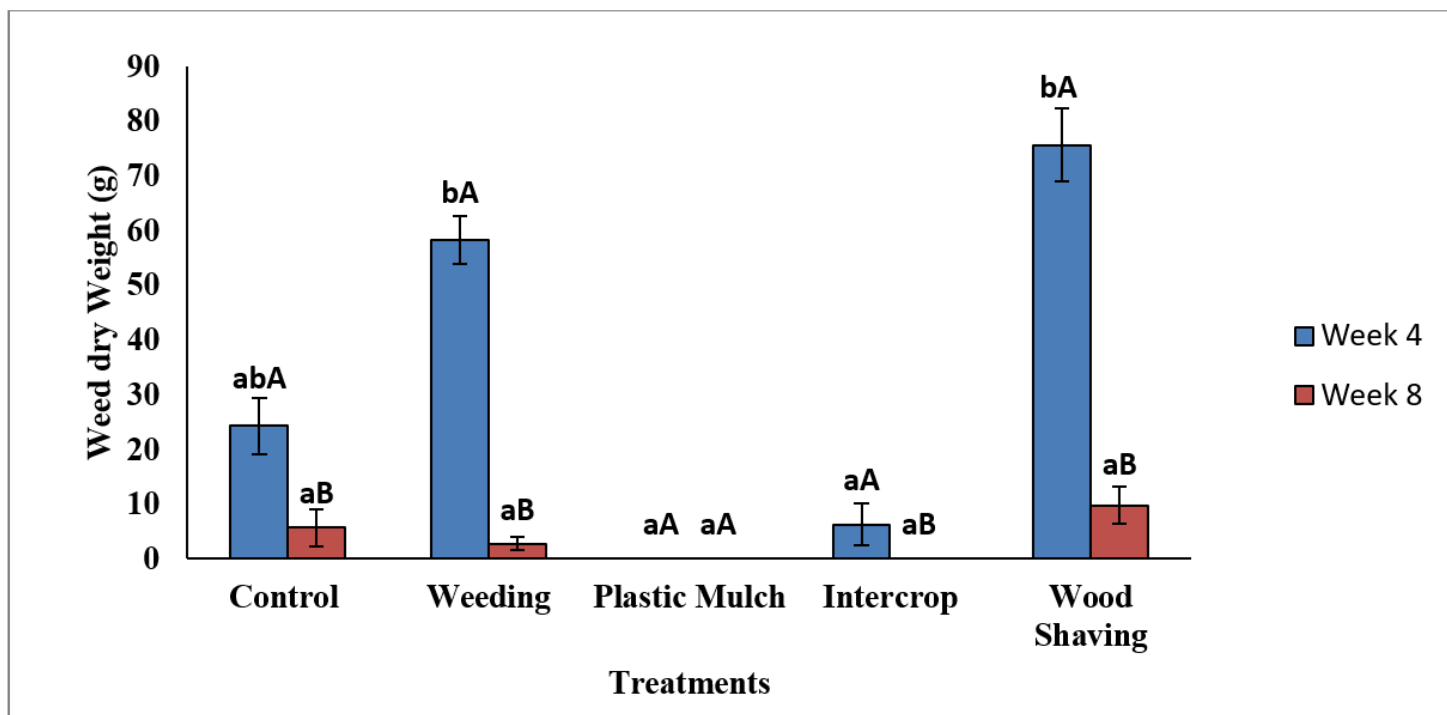


Figure 1

Weed dry weight at 4 and 8 weeks after planting. Bars with different lowercase letters indicate significant differences among treatments within the same week, while different uppercase letters indicate significant differences between weeks within the same treatment (Tukey's HSD test,  $P < 0.05$ ).

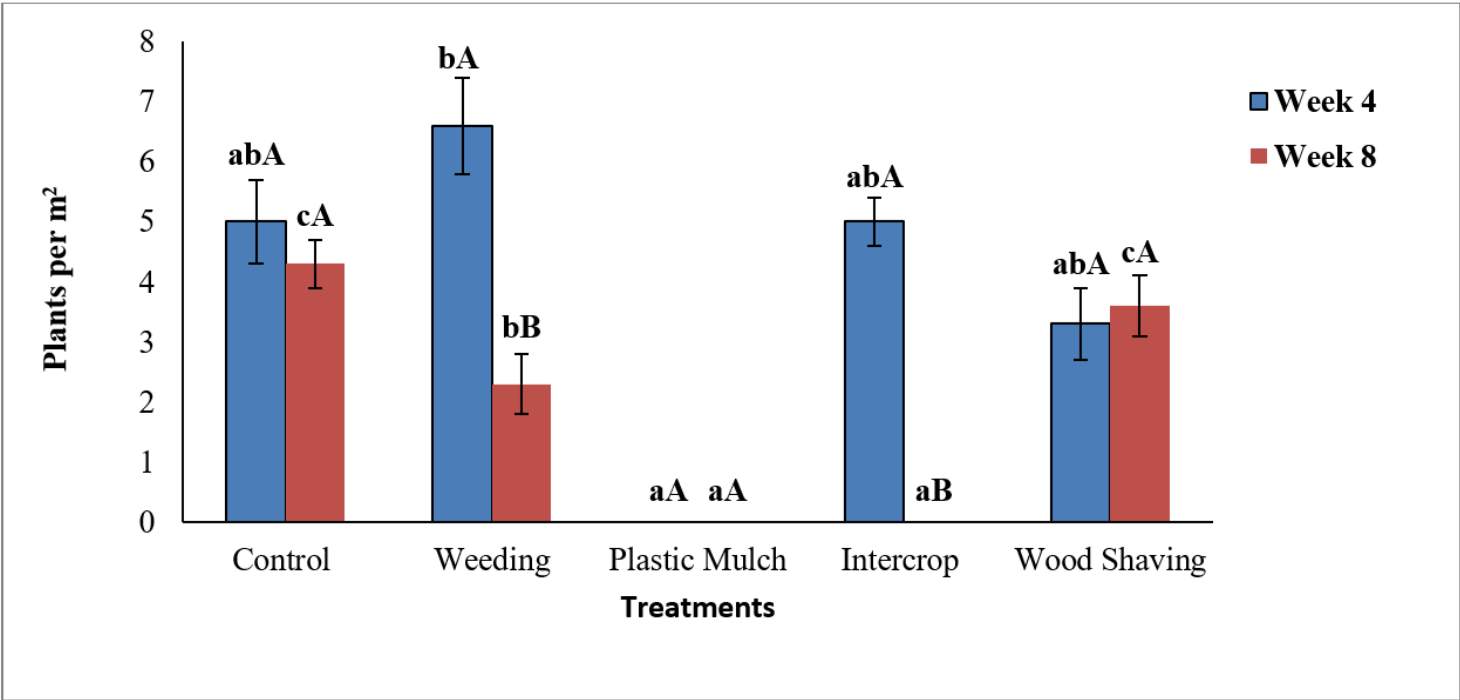


Figure 2

Weed density at 4 and 8 weeks after planting. Bars with different lowercase letters indicate significant differences among treatments within the same week, while different uppercase letters indicate significant differences between weeks within the same treatment (Tukey's HSD test,  $P < 0.05$ ).

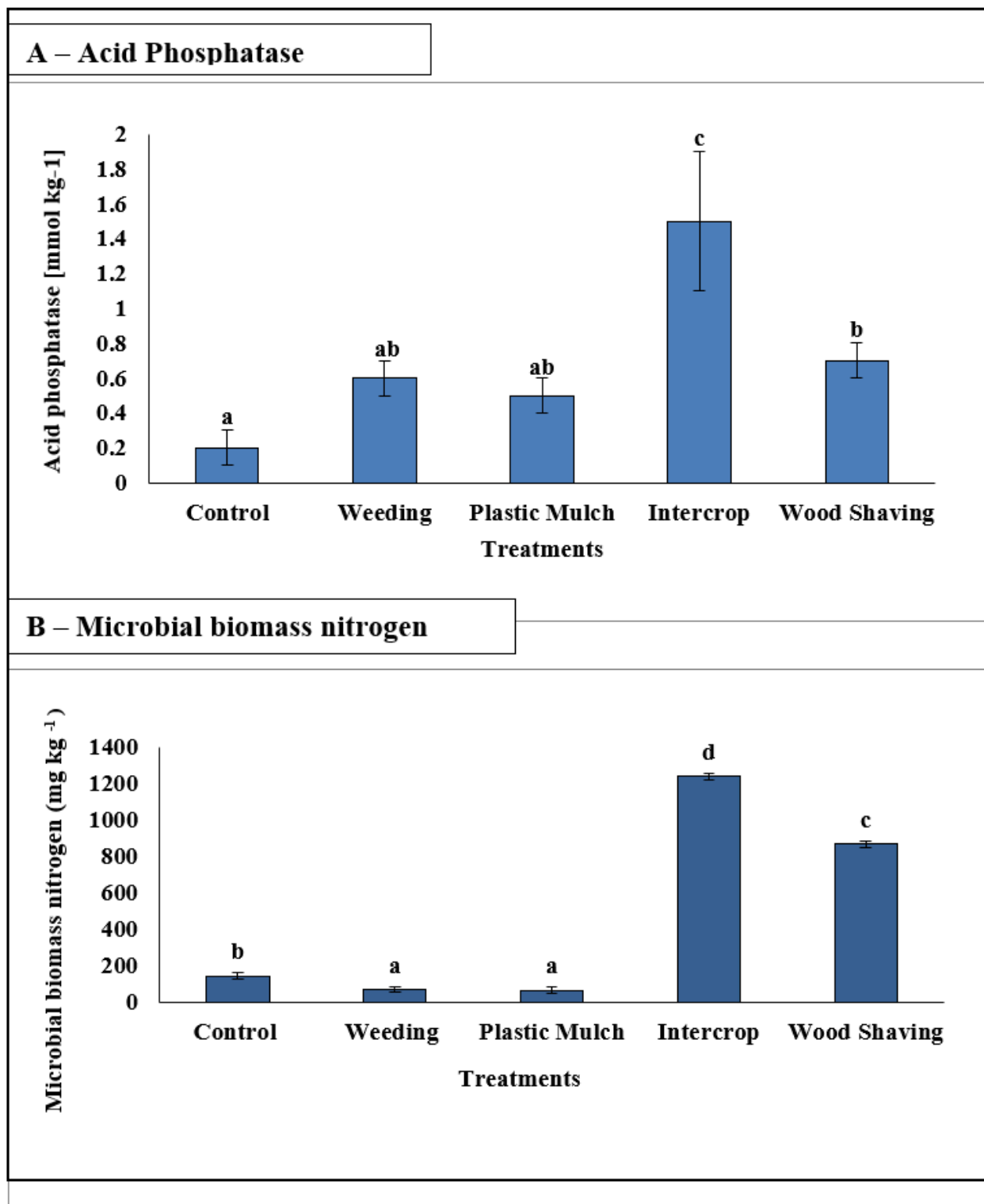


**Figure 3**

Soil microbial activities: (A) acid phosphatase and (B) microbial biomass nitrogen as influenced by weed management methods. Bars with different lowercase letters represent significant differences among treatments (Tukey's HSD test,  $P < 0.05$ ).

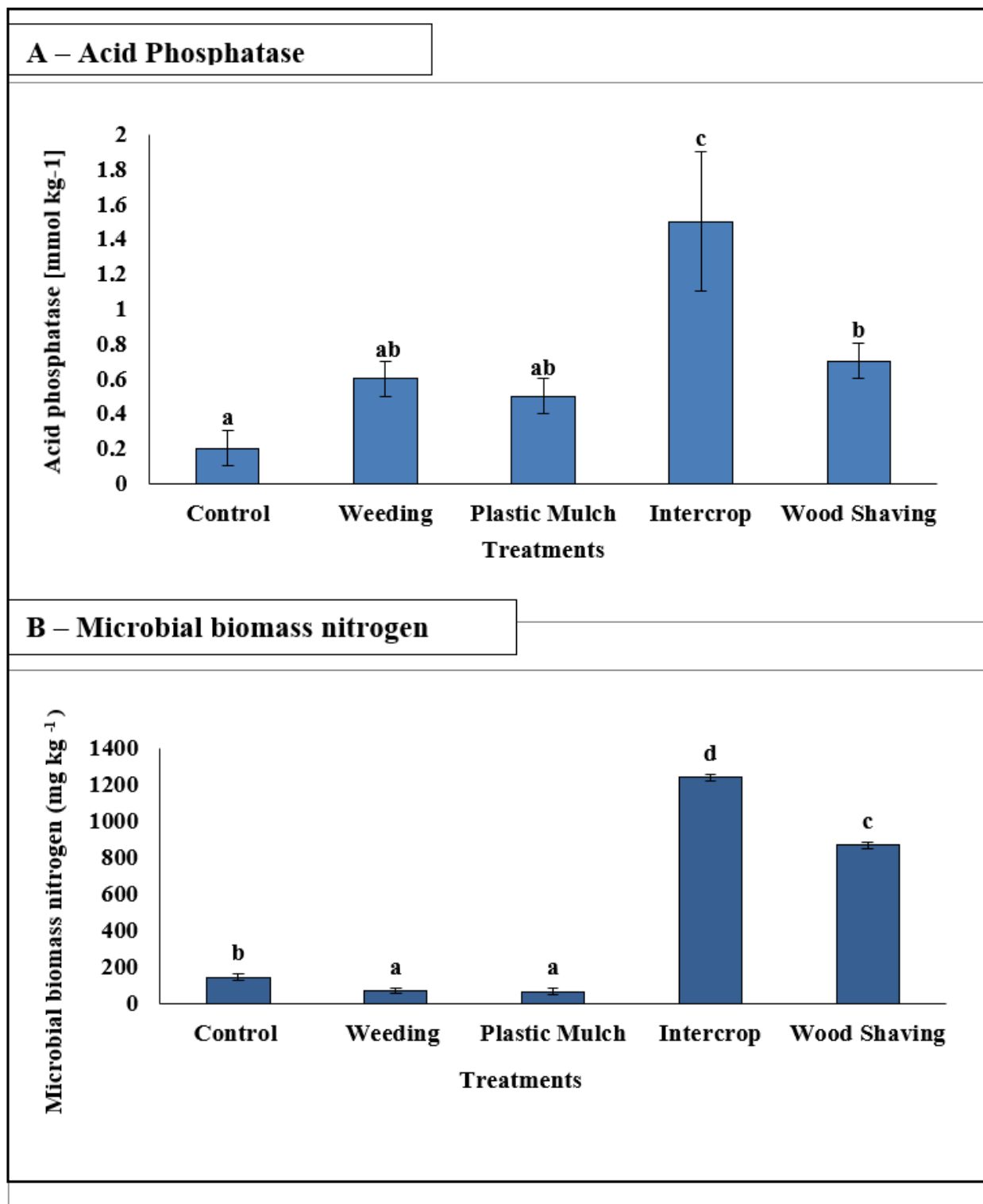


**Figure 3**

Soil microbial activities: (A) acid phosphatase and (B) microbial biomass nitrogen as influenced by weed management methods. Bars with different lowercase letters represent significant differences among treatments (Tukey's HSD test,  $P < 0.05$ ).

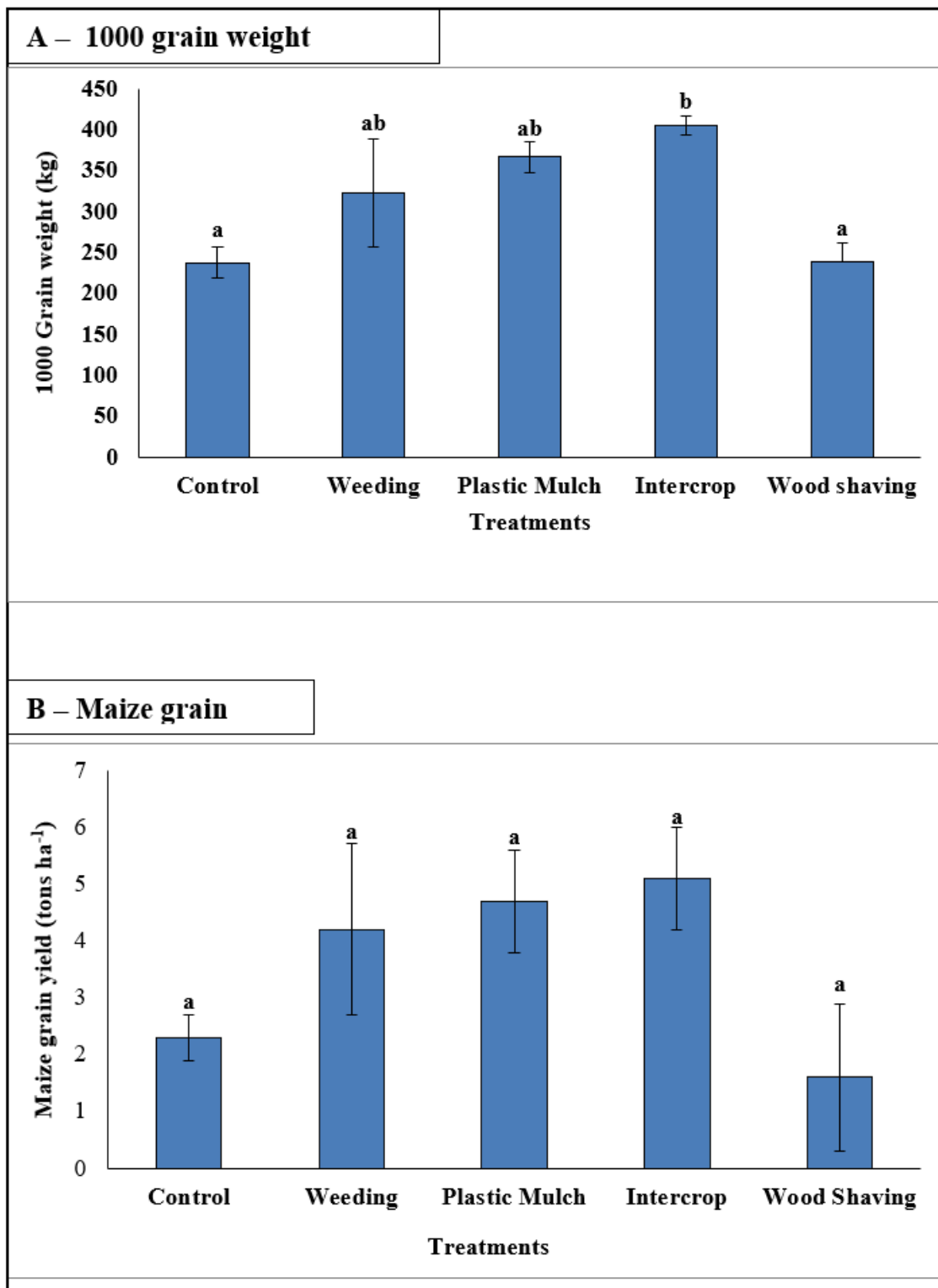


**Figure 4**

Maize yield parameters: (A) 1000-grain weight and (B) grain yield as influenced by weed management methods. Bars with different lowercase letters represent significant differences among treatments (Tukey's HSD test,  $P < 0.05$ ).

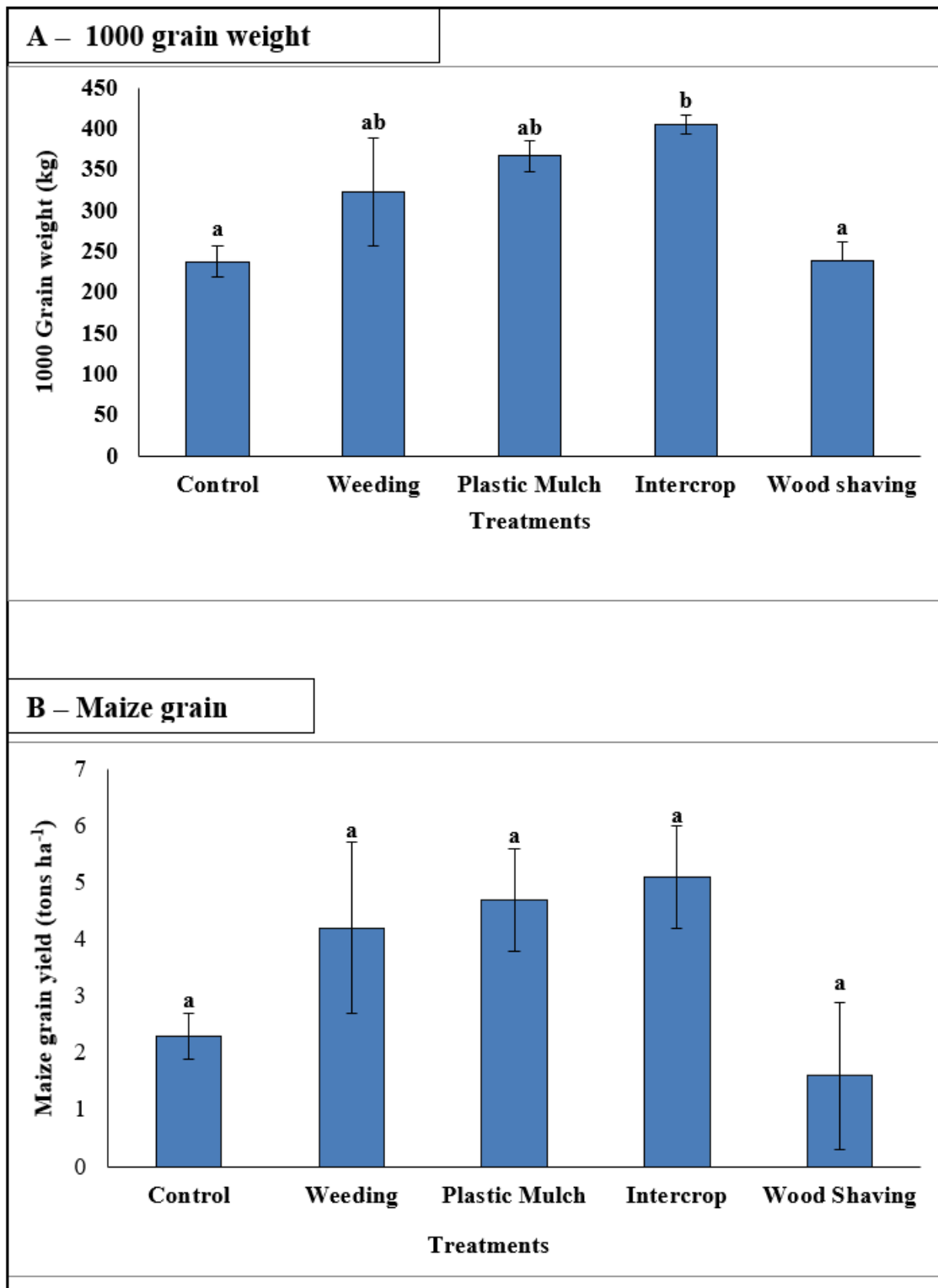


**Figure 4**

Maize yield parameters: (A) 1000-grain weight and (B) grain yield as influenced by weed management methods. Bars with different lowercase letters represent significant differences among treatments (Tukey's HSD test,  $P < 0.05$ ).