

Optimising Groundnut (*Arachis Hypogaea* L.) Yield: The Impact of Tillage Systems and Integrated Weed-Control Strategies on Growth, Soil Properties, and Productivity

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ABSTRACT

While the low yield of groundnuts is attributed mostly to poor tillage practices, weed infestation significantly affects the yield of groundnuts. Thus, this study aimed to evaluate the effect of tillage systems and weed-control methods on the growth and yield of groundnut and soil physical properties. A two-factor experiment comprising tillage (complete and minimum) and weed control (control, free weed check, hand weeding at 20 and 60 DAS, Metropole pre-emergence herbicide at 480g/l/ha, Paraq post-emergence herbicide at 200g/l/ha, integrated Metropole at 240g/l/ha, Paraq at 100g/l/ha and hand weeding) was conducted at the University of Buea, randomly assigned with three replicates. The results showed that tillage systems and weed control methods, and their interaction, had a significant effect on groundnut growth parameters. The yield of groundnut was higher in complete tillage (2.09t/ha), while free weed check had a higher yield (2.59t/ha), and complete tillage interaction with free weed check had the highest yield (2.85t/ha). The soil moisture, bulk density, and porosity were significantly influenced by different tillage practices and weed control methods. All weed control methods effectively reduced weed density, increased species richness and decreased abundance, hence improved groundnut yield. It is observed that conventional tillage in combination with hand-weeding or weed-free check is recommended for effective weed control and improvement of groundnut yield.

Keywords

Tillage system, Weed control, Yield, Soil physical properties, Groundnut.

Introduction

Groundnut is extensively cultivated worldwide due to its high nutritional value and its significant role in enhancing soil fertility.

As a rich source of oils, proteins, and carbohydrates, groundnut serves as a crucial component of both human diets and livestock feed [1]. Beyond its dietary importance, groundnut contributes to soil health through biological nitrogen fixation and by returning organic matter to the soil, thereby improving soil structure and fertility [2].

Despite these benefits, groundnut productivity in Cameroon remains suboptimal. The country's average annual production is approximately 536,187 tons from 377,496 hectares, translating to a modest yield of 1.42 tons per hectare [3]. In northern Cameroon, groundnut is a staple crop, ranking third in area cultivated after cotton and major cereals such as sorghum, millet, and maize [4]. The persistently low yields are attributed to a combination of challenges, including climate variability, the use of inferior seed varieties, pest and weed infestations, expansion onto marginal lands, and suboptimal tillage practices [5].

In addition to weed management, soil tillage practices play a pivotal role in groundnut cultivation, influencing both crop yield and environmental outcomes such as soil erosion. Traditional tillage has long been practised to suppress weeds and enhance soil water and nutrient availability [9]. However, recent research suggests that minimum tillage may offer agronomic and environmental advantages over conventional tillage, including improved soil quality [9]. Despite these benefits, many farmers remain hesitant to adopt minimum tillage due to concerns about potential yield reductions and increased harvesting losses [10]. As a result, less than 30% of groundnut growers utilise conservation tillage, highlighting the need for further research to clarify the factors underlying variable responses to reduced [11].

Given these challenges, there is a critical need to systematically evaluate the combined effects of tillage systems and weed management practices on groundnut growth, yield, and soil physical properties. This study was therefore designed to investigate how integrating different tillage regimes with weed control methods influences groundnut productivity and soil health. We hypothesise that the synergistic application of effective weed management and appropriate tillage systems will enhance groundnut yield while simultaneously improving soil physical characteristics.

Materials and Methods

Experimental Site

The field experiment was conducted at the University of Buea, Cameroon, situated at the foothills of Mount Cameroon. The soil in this area is generally fertile but characterised by low moisture retention capacity. The site experiences a monomodal rainfall pattern with relative humidity ranging between 85% and 90%. The heavy rainfall season spans from June to October, receiving an average annual precipitation of approximately 2085 mm. The dry season occurs from October to March, with monthly temperatures fluctuating between 19°C and 30°C. Soil temperatures measured at a 10 cm depth decrease from 25°C to 15°C as elevation increases from 200 to 2200 meters above sea level [12,13].

Experimental Design and Treatment Application

A two-factor factorial experiment was designed to evaluate the effects of tillage systems and weed control methods on groundnut performance. The experiment was arranged in a completely randomised design with three replicates. The factors included; tillage systems: *T1* (conventional tillage involving the preparation of beds measuring 3 m × 3 m), *T2* (minimum tillage, with seeding

performed at a depth of 5 cm), and weed control methods: *W1*:(untreated control), *W2* (weed-free check, maintained by manual weeding every two weeks), *W3* (pre-emergence application of Metropole herbicide at 480 g/L metribuzin active ingredient per hectare, applied one week before sowing), *W4* (post-emergence application of PARAQ herbicide at 200 g/L paraquat active ingredient per hectare, applied at 20 and 60 days after sowing (DAS)), *W5* (two manual weeding performed at 20 and 60 DAS) and *W6* (combined treatment of Metropole at 240 g/L metribuzin active ingredient one week after sowing, PARAQ at 100 g/L paraquat active ingredient at 30 DAS, followed by hand weeding at 60 DAS).

Each treatment combination was replicated thrice, with plots separated by 0.5 m alleys and 1 m spacing between blocks. Beds were uniformly sized at 3 m × 3 m.

Field Preparation and Planting

The experimental field was cleared, demarcated, and divided into blocks corresponding to the tillage treatments. Conventional tillage plots were prepared by ridge formation and raising beds approximately 20 cm above ground level. Minimum tillage plots involved soil disturbance limited to 5 cm depth during sowing. Groundnut seeds were sown at a spacing of 25 cm × 25 cm, at a depth of 3–5 cm, with one seed per stand, resulting in approximately 100 plants per bed and an estimated density of 160,000 plants per hectare [14].

Crop Management

Supplemental watering was applied to maintain field capacity during dry spells, ensuring adequate moisture for optimal growth. This was followed by earthing up, where soil was heaped around the base of plants to prevent root exposure and enhance stability. Weed control was conducted as per the assigned treatment protocols.

Data Collection

Growth and Yield Parameters

Twenty plants per plot were randomly selected and tagged for monitoring. Data on plant height, number of leaves, branches, and flowers were collected at 30, 45, 60, 75, and 90 DAS. At harvest, pod yield per treatment was measured using an electronic balance.

Soil Physical Properties

Soil bulk density and moisture content were determined following standard protocols described by Gupta et al. [15], and soil total porosity was calculated as described by Chancellor [16].

Weed Assessment

Before and after treatment application, weed density data were collected using a 1 m² quadrat randomly placed within each plot. Weed species were identified and counted individually [17].

Weeds within the quadrats were uprooted, cleaned, and sorted by species. Fresh weight was measured using an electronic scale. Samples were then oven-dried at 70°C for 72 hours, after which dry weights were recorded and expressed in grams per square meter.

Species richness was calculated by summing the total weed species per plot. Species diversity was estimated using the Shannon-Wiener index [18], and evenness based on [19].

Statistical Analysis

Data were organised using Microsoft Excel 2013 and analysed using Analysis of Variance (ANOVA) to determine the significance of treatment effects at a 5% probability level. The General Linear Model (GLM) was used to test for interaction effects. Data not meeting normality assumptions were log-transformed prior to analysis. Significant means were separated using Tukey's Honest Significant Difference (HSD) test at $\alpha = 0.05$. All statistical analyses were performed using Minitab Version 17.

Weed competition is particularly detrimental to groundnut, given the crop's slow initial growth and short stature, especially during the first 40 days after planting. Weeds not only compete aggressively for nutrients, water, light, and space, but also serve as hosts for insect pests and disease vectors, and may produce allelochemicals harmful to groundnut. Consequently, weed management is a critical determinant of groundnut productivity, with unchecked weed growth responsible for yield losses of up to 47% [6]. Rapid weed emergence and growth during the early crop stages have been shown to significantly reduce groundnut yields [7,8]. Therefore, implementing effective weed control strategies is essential for optimising groundnut production.

Result

Tillage systems and weed control methods modulated groundnut growth parameters

The effect of tillage systems on groundnut growth was evident, with the complete tillage system resulting in significantly greater plant height (20.6 cm) compared to minimum tillage. This positive impact of complete tillage extended to other vegetative parameters, including the number of leaves, branches, and flowers, as shown in Table 1. Weed control strategies also played a crucial role in enhancing groundnut growth. The weed-free check treatment produced the tallest plants (23.6 cm), and this trend was consistent for the number of leaves, branches, and flowers, where the weed-free check consistently outperformed other weed management approaches (Table 1).

Although the interaction between tillage systems and weed control methods did not yield statistically significant differences in groundnut growth parameters, observational data indicated that the combination of complete tillage and weed-free check provided the most pronounced improvements in all measured growth attributes. These findings underpin the importance of integrated soil and weed management practices in optimising groundnut vegetative development.

Tillage systems and weed control methods modulated groundnut yield

The impact of tillage systems on groundnut yield was pronounced, as illustrated in Figure 1. Complete tillage resulted in a significantly higher yield (2.09 t/ha) compared to minimum tillage (1.46 t/

ha), highlighting the advantage of thorough soil preparation for maximising groundnut productivity. Weed management practices also had a substantial influence on yield outcomes (Figure 2). Among the methods tested, the weed-free check produced the highest yield (2.59 t/ha), underscoring the critical role of effective weed control in optimising groundnut harvests.

Table 1: Sole and interactive effects of tillage systems and weed control methods on groundnut growth parameters.

Properties	Plant height (cm)	Number of leaves	Number of branches	Number of flowers
Tillage (T)				
Complete tillage	20.6 ^a	283.2 ^a	10 ^a	13 ^a
Minimum tillage	19.7 ^b	278.1 ^b	9 ^a	12 ^b
Weed control method (W)				
Control	16.8 ^c	256.7 ^f	7 ^d	9 ^d
Integrated	22.3 ^b	292.5 ^b	11 ^b	14 ^{ab}
Post-herb	19.6 ^c	280.8 ^c	9 ^c	13 ^b
Pre-herb	18.1 ^d	264.5 ^c	8 ^d	11 ^c
Two-handed weeding	20.5 ^c	277.2 ^d	9 ^c	12 ^c
Weed-free check	23.6 ^a	312.5 ^a	12 ^a	15 ^a
T x W interactions				
Complete tillage x Control	17.1 ^a	259.3 ^a	7 ^a	9 ^a
Complete tillage x Integrated	22.8 ^a	295.0 ^a	11 ^a	14 ^a
Complete tillage x Post-herb	20.1 ^a	283.3 ^a	10 ^a	13 ^a
Complete tillage x Pre-herb	18.6 ^a	267.0 ^a	8 ^a	11 ^a
Complete tillage x Two-hand weeding	21.0 ^a	279.7 ^a	9 ^a	12 ^a
Complete tillage x Weed-free check	24.0 ^a	315.3 ^a	13 ^a	15 ^a
Minimum tillage x Control	16.5 ^a	254.0 ^a	7 ^a	8 ^a
Minimum tillage x Integrated	21.8 ^a	290.0 ^a	11 ^a	13 ^a
Minimum tillage x Post-herb	19.1 ^a	278.3 ^a	9 ^a	12 ^a
Minimum tillage x Pre-herb	17.6 ^a	262.0 ^a	7 ^a	10 ^a
Minimum tillage x Two-hand weeding	20.0 ^a	274.7 ^a	8 ^a	11 ^a
Minimum tillage x Weed-free check	23.2 ^a	309.7 ^a	12 ^a	14
T	0.02	0.000	0.07	0.04
W	0.000	0.000	0.000	0.000
T x W	1	1	1	1

Mean values with different superscripts indicate significant differences ($P < 0.05$).

Furthermore, the interaction between tillage systems and weed control methods produced significant differences in yield performance (Figure 3). The combination of complete tillage and weed-free check yielded the greatest productivity, achieving

2.85 t/ha. This finding demonstrates the synergistic benefit of integrating comprehensive tillage with rigorous weed management for enhancing groundnut yield potential.

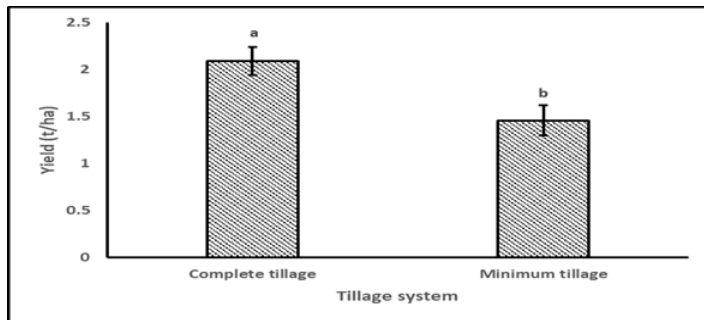


Figure 1: Tillage systems modulation of groundnut yield. Bars sharing the same letter are not statistically significant ($P = 0.004$).

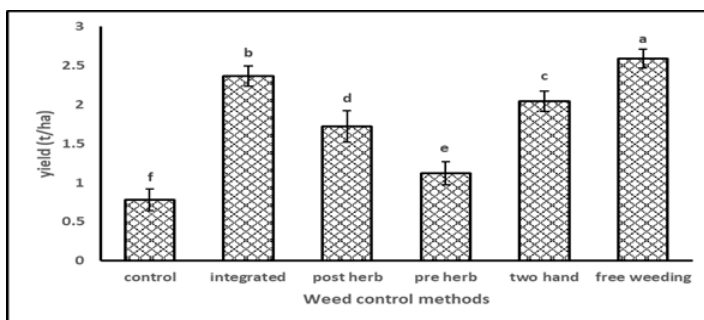


Figure 2: Weed control methods modulation of groundnut yield. Bars sharing the same letter are not statistically significant ($P = 0.000$).

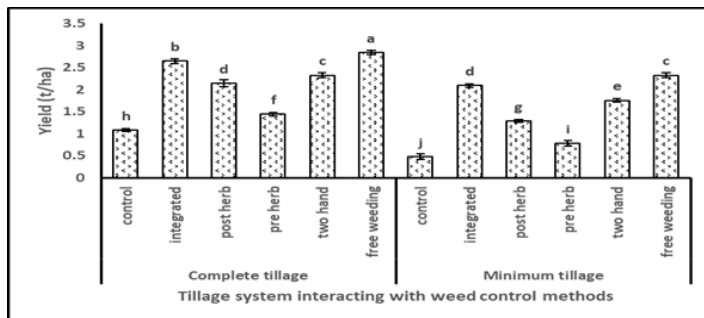


Figure 3: Tillage systems and weed control methods interactions modulated of groundnut yield. Bars sharing the same letter are not statistically significant ($P = 0.05$).

Tillage systems and weed control methods modulation effect on soil physical parameters

The complete tillage system demonstrated a notable impact on soil physical properties, yielding a higher bulk density (4.98 g/cm³) compared to zero tillage. This trend was mirrored in soil moisture content, which was also greater under complete tillage (117.4), indicating improved water retention capacity. Although no statistically significant difference was observed in soil porosity between the tillage systems, complete tillage resulted in slightly higher porosity (2.26), suggesting enhanced soil structure (Table 2). Weed management strategies significantly affected soil bulk density, with the lowest value (5.19 g/cm³) recorded under the

weed-free check treatment (Table 2). The weed-free check also produced the highest soil moisture content (121.4) and exhibited the most favourable soil porosity, reinforcing the positive influence of effective weed control on soil physical conditions (Table 2). No significant interactive effects between tillage systems and weed control methods were detected for any of the measured soil parameters, indicating that their contributions to soil bulk density, moisture, and porosity were independent (Table 2). These findings highlight the importance of both tillage and weed management practices in maintaining optimal soil health for groundnut cultivation.

Table 2: Sole and interactive effects of tillage systems and weed control methods on soil parameters.

Properties	Bulk density (g/cm ³)	Soil moisture	Soil porosity
Pre-planting soil (complete tillage)	5.35	126.8	2.06
Pre-planting soil (minimum tillage)	7.04	111.8	2.65
Tillage (T)			
Complete tillage	4.98 ^b	117.4 ^a	2.26 ^a
Minimum tillage	5.98 ^a	115.4 ^b	2.03 ^a
Weed control method (W)			
Control	5.74 ^a	112.4 ^c	2.06 ^b
Integrated	5.52 ^c	114.4 ^d	2.13 ^b
Post-herb	5.55 ^{bc}	115.2 ^{cd}	2.09 ^b
Pre-herb	5.63 ^b	116.5 ^c	2.11 ^b
Two hand weeding	5.23 ^d	118.6 ^b	2.19 ^{ab}
Weed free check	5.19 ^d	121.4 ^a	2.29 ^a
T x W interactions			
Complete tillage x Control	5.24 ^a	113.6 ^a	2.18 ^a
Complete tillage x Integrated	5.02 ^a	115.4 ^a	2.23 ^a
Complete tillage x Post-herb	5.05 ^a	116.1 ^a	2.21 ^a
Complete tillage x Pre-herb	5.13 ^a	117.4 ^a	2.19 ^a
Complete tillage x Two hand weeding	4.73 ^a	119.7 ^a	2.32 ^a
Complete tillage x Weed free check	4.69 ^a	122.3 ^a	2.44 ^a
Minimum tillage x Control	6.24 ^a	111.2 ^a	1.95 ^a
Minimum tillage x Integrated	6.02 ^a	113.4 ^a	2.03 ^a
Minimum tillage x Post-herb	6.05 ^a	114.4 ^a	2.01 ^a
Minimum tillage x Pre-herb	6.13 ^a	115.6 ^a	1.98 ^a
Minimum tillage x Two hand weeding	5.73 ^a	117.4 ^a	2.06 ^a
Minimum tillage x Weed free check	5.69 ^a	120.5 ^a	2.14 ^a
T	0.000	0.001	1
W	0.000	0.000	0.03
T x W	1	1	1

Mean values with different superscripts indicate significant differences ($P < 0.05$).

The Effect of Interaction Between Tillage System and Time on Some Soil Parameters

Bulk density exhibited a notable reduction in both tillage systems throughout the growing season. Under complete tillage, bulk density decreased from 5.35 g/cm³ before harvest to 4.98 g/cm³ after harvest, reflecting improved soil structure with crop growth and management. Similarly, minimum tillage plots showed a decline in bulk density from 7.04 g/cm³ to 5.98 g/cm³ post-harvest (Figure 4), though values remained higher than those observed under complete tillage.

Soil moisture content under complete tillage declined from 126.8 units before harvest to 112.63 units after harvest, likely due to plant uptake and evapotranspiration as the crop matured. In contrast, minimum tillage plots experienced a modest increase in soil moisture, reaching 111.99 units after harvest (Figure 5), possibly reflecting reduced soil disturbance and enhanced moisture conservation. Regarding soil porosity, Figure 5 illustrates temporal changes across tillage systems. In complete tillage, porosity increased from 2.06 ± 0.03 before harvest to 2.17 after harvest, indicating improved soil aeration and aggregation. Conversely, minimum tillage plots saw a decrease in porosity from 2.65 before harvest to 2.17 after harvest, ultimately converging with the values observed in complete tillage. These results collectively demonstrate that tillage practices influence dynamic changes in soil physical properties throughout the cropping cycle, with complete tillage generally promoting more favourable post-harvest soil conditions for groundnut cultivation.

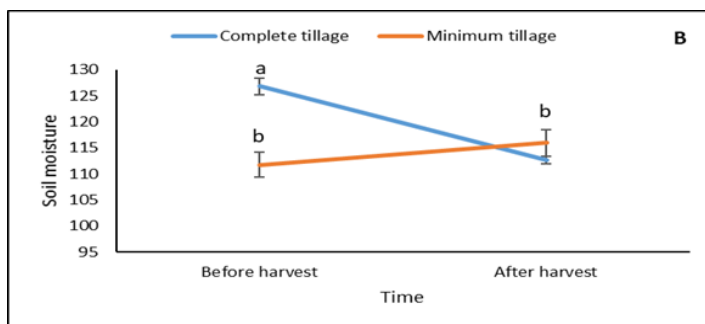


Figure 4: Changes in soil moisture as affected by tillage systems over time. The error bars represent Tukey's test at $\alpha = 0.05$.

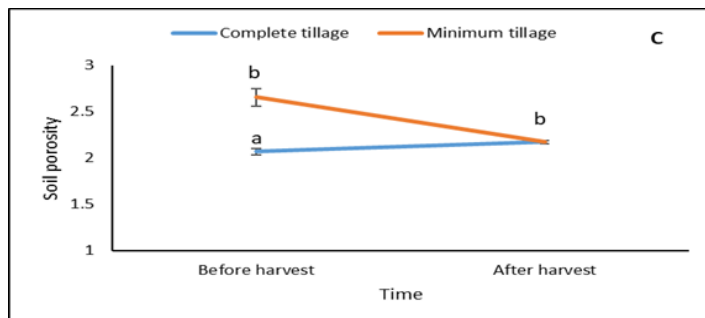


Figure 5: Changes in soil porosity as affected by tillage systems over time. The error bars represent Tukey's test at $\alpha = 0.05$.

Changes in Weed Diversity, Species Richness, Abundance and Biomass over time in Plots Planted with Groundnuts

Following the application of treatments, weed species diversity exhibited a significant increase, rising from a pre-harvest value of 1 to 2 after harvest. Similarly, species richness showed a marked enhancement, increasing from 7 species before treatment to 10 species post-treatment application. In contrast, weed abundance demonstrated a notable decline, decreasing from 164 individuals before treatment to 88 after treatment, as illustrated in Figure 6. Despite the reduction in weed abundance, total weed biomass increased substantially, from 15 units before treatment to 78 units

after treatment (Figure 7). This suggests that while the number of individual weeds was reduced, the remaining weed species were able to accumulate greater biomass, potentially due to reduced competition or shifts in species composition. These findings highlight the complex dynamics of weed communities in response to management interventions, emphasising the importance of integrated strategies for effective weed control in groundnut cultivation.

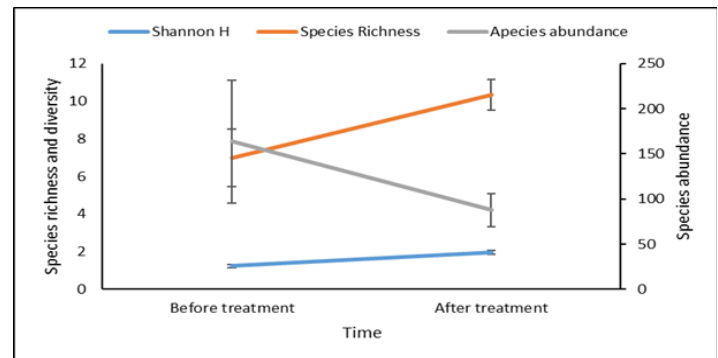


Figure 6: Changes in species diversity, richness and abundance over time. The error bars represent Tukey's test at $\alpha = 0.05$.

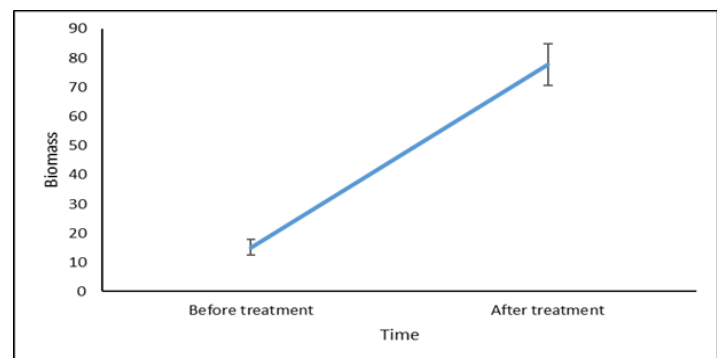


Figure 7: Changes in weed biomass over time. The error bars represent Tukey's test at $\alpha = 0.05$.

Checklist of Weeds Found in the Groundnut Production Field

A three distinct species and thus emerging as the most dominant family within the weed comprehensive survey of the experimental field, identified a total of 15 weed species distributed across 11 botanical families (Table 3). The Asteraceae family exhibited the greatest diversity, contributing flora. This was followed by the Poaceae and Amaranthaceae families, each represented by two species. The remaining families contributed one species apiece. These findings underscore the predominance of Asteraceae in the weed community, reflecting its well-documented adaptability and competitive advantage in agricultural ecosystems.

Discussion

Effect of Tillage and Weed Control Methods on Groundnut Growth and Yield

The measured parameters varied significantly across applied treatments. Tillage systems significantly influenced plant height, with minimal tillage being lower than complete tillage. The reason

could be due to competition between the plants and weeds for sunlight, leading to etiolation as a result of minimal weed control, which is consistent with the findings of Chetan et al. [20], who stated that complete tillage resulted in taller tomato plants while reduced tillage resulted in short-stature plants. The tallest plants were recorded in the free weed check method under complete tillage. This result is similar to that of Khan et al. [21] who opined that weeding significantly affected plant height. Weeding facilitates plants to have more resources for growth and production due to a reduction in interspecific competition below and above-ground competition. Increasing the weeding frequency led to higher plant height, due to efficient weed control. This is also following the findings of Gnanasundari et al. [22], which stated that maximum plant height was recorded in the weed-free treatment.

Complete tillage had more leaves compared to those under minimum tillage systems, which is in line with Mishra et al. [23]. The reduction in competition for nutrients, moisture and sunlight also led to an increase in the number of leaves per plant. Plants under free weed check had more leaves, aligning with Hanif et al. [24] who attributed proper weed control to weeding at an appropriate frequency.

More branches were counted in completely tilled plots. The probable reason for more branches in complete tillage might be because of lesser competition of groundnut with weeds for soil moisture and nutrients [25]. With regards to weed control methods, plants under free weed check had more branches [21]. This result may be attributed to vigorous plant growth accompanied by less competition for light, nutrients, water and space in weed-free plots.

A higher significant yield was recorded in complete tillage compared to the yield recorded in minimal tillage plots. This increase in yield might be due to well aerated soils, favourable soil moisture and efficient nutrient uptake. According to Richards [26], many growers prefer planting on raised beds rather than flat planting. The beds provide favourable conditions for germination,

root proliferation, seedling establishment, seedling development, and provide drainage and may reduce pod losses during harvest [27]. According to Weber et al. [9], plant density in minimal tillage should be increased to ensure similar yields in complete tillage. Despite these demerits, minimum tillage can improve the sustainability of groundnut production by reducing fuel and labour costs, as well as reducing the risk of erosion. Higher significant yield was found in plots with free weed check. This was because the crop plants experienced good vegetative growth right from the early stages of growth to the end of the cropping period, because of less competition with weeds for nutrients, water, space, and sunlight, which might have resulted in higher photosynthetic activity [7].

The Effect of Tillage and Weed Control Methods on Soil Physical Properties

Soil moisture, soil bulk density and soil porosity were influenced by tillage system and weed control methods. There was no significant interaction between the tillage system and the weed control methods. The weed control method significantly influenced soil moisture. Tillage could be another important field operation that helps in weed control. Yaseen et al. [25] reported that deep tillage convincingly controls or reduces weed populations in maize as compared to reduced tillage practices. Complete tillage not only preserves soil moisture and ensures better crop growth but also disturbs the weed seed bank in the soil, and most of the weed seeds are not able to germinate either due to exposure to the sun or being buried too deeply. Soil moisture is the single most limiting factor to crop yields, and thus, tillage techniques that conserve moisture are important for increasing crop yields and limiting the devastating consequences of drought [28]. Soil moisture dropped before harvest and increased after harvest may be a result of the weed management methods and increased rainfall during this period of crop growth.

The bulk density of soils in plots under minimum tillage was significantly higher compared to soils under the complete tillage

Table 3: Checklist of weeds found in the groundnut production system in Buea.

S/N	Family	Scientific name	Common name	Life form	Leaf morphology	Number of individuals per species	Total per family
1	Amaranthaceae	<i>Achyranthes aspera</i> L	Devils horsewhip	Annual	Broadleaf	20	37
		<i>Amaranthus spinosus</i> L	Spiny amaranth	Annual	Broadleaf	17	
2	Asteraceae	<i>Ageratum conizoides</i> L	Billygoat weed	Annual	Broadleaf	518	578
		<i>Bidens Pilosa</i>	Black jack	Annual	Broadleaf	13	
		<i>Emilia fosbergii</i> L	Florida tasselflower	Annual	Broadleaf	10	
3	Cleomaceae	<i>Cleome rutidosperma</i> DC	Consumption weed	Annual	Broadleaf	34	34
4	Commelinaceae	<i>Commelina diffusa</i> L	Climbing day flower	Annual	Broadleaf	56	56
5	Curcubitaceae	<i>Momordica balsamina</i> L	Balsam- apple	Annual	Broadleaf	19	19
6	Euphobiaceae	<i>Euphobia heterophylla</i> L	Japanese poinsettia	Annual	Broadleaf	25	25
7	Poaceae	<i>Eleusine indica</i> L	Crowfoot grass	Annual	Narrow	402	442
		<i>Digitaria sanguinalis</i> L	Hairy crabgrass	Annual	Narrow	40	
8	Portulacaceae	<i>Portulaca oleracea</i> L	Common purslane	Annual	Broadleaf	21	21
9	Oxalidaceae	<i>Oxalis barrelieri</i> L	Barreliers	Annual	Broadleaf	12	12
10	Talinaceae	<i>Talinum fruticosum</i> L	Water leaf	Annual	Broadleaf	7	7
11	Urticaceae	<i>Parietaria Judaica</i> L	Pellitory-of-the-wall	Annual	Broadleaf	14	14

system. Similar results were also recorded by Topa et al. [29], who stated that tillage practices significantly influenced the bulk density. This may be as a result of the fact that under reduced tillage, there is better control of soil erosion and conservation of soil moisture. Merga and Alemu [30] also had similar results and stated that this might be due to lower temperature and rainfall at early crop emergence. The bulk density of soil was statistically similar in the weed-free check plots and the two hand-weeded plots. Weed-free check and two-hand weeding showed a slight decrease in bulk density. High bulk density in the other weed control methods was a result of lower pore space among soil particles, which leads to higher compaction, which reduces the availability of nutrients and reduces root growth and proliferation into the soil [31].

Concerning porosity, soils under the minimum tillage system were less porous compared to soils under the complete tillage system. Many studies have indicated that tillage systems significantly influence the soil pore size distribution. This agrees with the findings of Gao et al. [32] who reported that total porosity was similar under different treatments, and also with the work of Pires et al. [33] who stated that increased soil porosity in complete tillage might be due to enhanced disturbance of the soil. Increase in porosity over time was as a result of the fact that weed control methods increase incorporation especially in the hand weeded treatments which help to improve the soil nutrient holding capacity, reduce evaporation from the soil and improve available plant water-released nutrients for the crop growth reported by Saini et al. [34] which aligns with the findings of this study.

Determination of the Effect of Tillage and Weed Management on Weed Control and Weed Diversity

The major weed flora observed in the experimental field included *Eleusine indica*, *Ageratum conyzoides*, *Commelina diffusa*, *Cleome ruidosperma*, *Achyranthes aspera*, and *Amaranthus spinosus*. Other minor weeds included *Talinum fruticosum*, *Bidens pilosa*, *Emilia fosbergii*, *Oxalis barrelier*, etc.

All weed species found in this field experiment were annual weeds with broad leaves, appearing more than the narrow leaves and accounted for about 80% of the total weeds found. A similar study conducted by Qureshi et al. [35] found that weed communities of wheat crop in district Toba Tek Singh, Pakistan had 38 weed species distributed among 35 genera and 17 families. In a similar study conducted by Migwi et al. [36] in Coffee estates in Kiambu County, Kenya, they reported 19 families comprising 47 weed species. Effective weed management is essential for profitable peanut production. Peanuts are not very competitive with weeds and thus require higher levels of weed control than most other agronomic crops to avoid yield losses. A weed management program in peanuts consists of good weed control in rotational crop cultivation, establishment of a satisfactory stand and growing a competitive crop, and proper selection and use of herbicides.

Species richness was low in the complete tillage systems, and Species abundance was significantly higher in the minimum tillage system compared to the complete tillage system. Crop

management strongly affects the abundance and diversity of weeds, and changes in tillage are likely to have a clear effect on the community structure [35]. Such changes in tillage may result in weed species shifts [37]. Alarcón et al. [38] reported that the abundance, diversity and evenness of the weed community in a wheat field were greatly increased in no-tillage systems. This may be as a result of the fact that weeds often become dominant after a period of no-tillage in which weed seeds are retained near the soil surface [39]. Gul et al. [40] reported that tillage reduced weed biomass. Lower weed biomass at higher plant population indicated that increasing plant population ensured uniform crop stand and covered the open niches, which otherwise might have been utilised by weeds. So, with increasing plant population, the chances of weed establishment were minimised. These results agree with the work of Ryan et al. [41] that increasing plant density reduced weed biomass. Due to effective weed control, the weeds in the hand weeding were destroyed through weeding. As in the case of weed biomass, tillage management was the most important factor for weed control practices determining species richness before and after treatment application, which is in accordance with Mishra et al. [42] findings in the maize production system. Changes in weed biomass and weed community composition are dependent on variations in agronomic practices and are a result of selection pressure. Studies indicate that minimum tillage, diversifying rotations, some fertiliser strategies, and combinations of these techniques can be effective methods of reducing weed density [43]. Control plots resulted in the highest weed density. The higher biomass of weeds in control plots might be due to the open soil surface and niches available to weeds for free aggressive growth. The variation in weed biomass as a result of different tillage practices could be attributed to their variable weed control methods, which is in line with the results of Yaseen et al. [25] in a tomato production system.

Conclusion

Tillage is the most favourable farming practice for groundnut production as it maximises plant growth attributes robustly and yield. It was also observed that the pre-emergence herbicide Metropole@ 480g/L metribuzin ai/ha is an effective weed control method before planting in a groundnut production system. The tillage system was a more effective tool than weed control methods in the management of the composition, density and biomass of weeds in the groundnut production system. The most prominent family of weed was the Asteraceae, with the dominant weed species being *Ageratum conyzoides*, *Eleusine indica*, *Euphorbia heterophylla* and *Digitaria species* in this setting. Soil physical properties in a groundnut production influence its growth and development, providing suitable knowledge on the crop response and facilitating harvesting techniques. Soil moisture had a greater influence on crop performance as it facilitates growth by providing a suitable medium for water and nutrient uptake.

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