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Weed Responses to Agroecological Practices in Sorghum-Cowpea Intercropping Systems in the Sudano-Sahelian Zone of Burkina Faso

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Abstract

This study investigates how agroecological practices such as ridge tillage and organic fertilization, influence weed species richness and development within sorghum-cowpea intercropping systems in the Sudano-Sahelian zone of Burkina Faso. A split-split plot field experiment conducted over two cropping seasons evaluated weed species richness, ground cover, and biomass under three tillage methods, four cropping systems, and four fertilization treatments. Data analyses were performed in R program using canonical correspondence analysis, permutational multivariate analysis of variance, IndVal method and generalized linear models. Results indicated that ridge tillage maintains the highest characteristic species richness (three species) but achieves the greatest reduction in weed biomass and ground cover. Indeed, ridge tillage showed the greatest reduction in weed biomass (17.59 ± 13.70 $g.m^{-2}$), decreasing weed biomass by 34% relative to conventional tillage and 33% relative to no-tillage. Additionally, mineral fertilization alone resulted in the highest weed ground cover representing increases of 35% compared to the unfertilized control and 18% compared to compost alone. Compost-based fertilization mitigated weed proliferation, demonstrating lower ground cover values. These results support the adoption of ridge tillage and organic fertilization as integrated weed management strategies, aligning with agroecological principles to enhance sustainability and resilience in West African smallholder farming systems.

Keywords

Agroecology, Biodiversity, Sustainable Farming Systems, Weed Management, West Africa

1. Introduction

In the Sudano-Sahelian zone of West Africa, agroecological practices are increasingly recognized as a viable strategy to enhance agricultural sustainability under conditions of limited rainfall, declining soil fertility, and constrained access to external inputs. Indeed, the urgent need to develop sustainable agricultural systems in this region stems from increasing climate variability, soil degradation, and socioeconomic constraints limiting farmers' access to conventional inputs [1]-[4]. Among the commonly adopted practices, cereal-legume intercropping, organic fertilization, and reduced tillage have been identified as key pillars for building resilient and productive cropping systems [5]-[7]. Intercropping cereals with legumes is a widespread and well-established practice in the region, shown to enhance crop diversity, land-use efficiency, and household food security [8] [9].

Weed biodiversity is a crucial yet understudied component of agroecosystem functioning, which plays an integral role in shaping ecological interactions and agronomic outcomes in such diversified systems [10]-[12]. Although extensive research in temperate and Mediterranean systems has advanced understanding of weed community responses to farming practices, including studies on functional traits, community assembly, and management strategies similar data are scarce in the context of West African smallholder systems [13]-[15]. Specifically, while the impacts of tillage intensity and fertilization methods on weed communities are well-documented in temperate regions, their effects under Sudano-Sahelian conditions remain poorly understood. In Burkina Faso especially, existing weed research has largely focused on monoculture systems involving staple crops such as rice and maize [16] or on parasitic species like *Striga hermonthica* (Delile) Benth. and *S. gesnerioides* (Willd.) Vatke, which pose significant threats to cereal-legume production systems [17]-[19]. As a result, there is limited understanding of how weed communities as a whole respond to integrated agroecological practices, including intercropping, soil organic amendments, and conservation tillage. This knowledge gap hinders the development of ecologically based weed management strategies that could reduce dependence on herbicides and agroecosystem external inputs.

Given the low levels of mechanization typical of Sudano-Sahelian smallholder systems, weed management is labour-intensive and constitutes a major production constraint [20]. Biodiversity-based agroecological strategies that optimize weed suppression while conserving functional plant diversity could therefore provide significant agronomic and ecological benefits compared to conventional approaches relying on intensive tillage and synthetic inputs [20] [21].

The theoretical basis for expecting differential weed responses to tillage intensity draws from disturbance ecology and trait-based environmental filtering principles [22] [23].

Tillage creates soil disturbance that increases habitat heterogeneity and stimulates germination from seed banks across multiple soil depths, with seeds being uniformly distributed throughout the soil profile and potentially accessing diverse microenvironments for establishment [21] [24]. In contrast, no-tillage systems restrict seedbed disturbance to the soil surface, concentrating seeds in the upper soil layers and favoring a narrower set of species with traits adapted to superficial germination and establishment [24]-[26].

Similarly, the form of nutrients supplied influences weed community development through resource-based filtering mechanisms and nutrient release dynamics [27] [28]. Indeed, mineral fertilizers provide nutrients in readily available forms, often promoting fast-growing, nitrophilous weed species [29]. Conversely, compost releases nutrients more gradually and influences soil biota activity, though effects on weed communities vary with organic matter source, environmental conditions, and species composition [30] [31].

Beyond their competitive interactions with crops, weeds can contribute important ecosystem services such as erosion control, pollinator support, water retention, and nutrient cycling [11] [32]. A functional perspective on weed biodiversity aligns with core agroecological principles emphasizing the integration of beneficial plant diversity into farming systems for enhanced resilience and productivity [10] [33] [34].

This study aims to contribute to the sustainable management of weeds in Sudano-Sahelian agricultural landscapes. Specifically, it aims to 1) assess the effects of agroecological practices compared to conventional agricultural practices on weed diversity within a sorghum-cowpea intercropping systems; and 2) evaluate the effects of agroecological practices compared to conventional agricultural practices on weed development (ground cover and biomass) under sorghum-cowpea intercropping systems. Based on the ecological frameworks outlined above. We expect that 1) weed species richness is higher under ridge tillage than under conventional tillage methods within sorghum-cowpea intercropping systems; and 2) weed development (ground cover and biomass) is lower under compost application than under sole mineral fertilization due to slower nutrient release patterns and enhanced soil biota activity suppressing dominant weed species.

2. Materials and Methods

2.1. Study Site

The experiment was conducted during the 2020 and 2021 cropping seasons at the Kouaré Research Station, located in the Sudano-Sahelian zone of Burkina Faso, particularly in the province of Gourma (**Figure 1**).

The study area is characterized by a distinct rainy season from May to October and a dry season from November to April. Climatic data (2020-2021) indicate that the site receives average annual precipitation of approximately 850 mm, with peak rainfall occurring in July, August, and September (**Figure 2**). During these months, monthly rainfall often exceeds 150 mm. Average monthly temperatures remain relatively stable throughout the year, ranging from 23˚C to 32˚C (**Figure 2**). According to the WRB (World Reference Base for Soil Resources), the main soil types in the study site include Regosols, Lixisols, Cambisols (**Figure 1**), which are typical of Burkina Faso and are moderately leached, with low fertility [35] [36]. These pedoclimatic conditions, characterized by seasonal rainfall, high temperatures, and sandy, nutrient-poor soils pose significant constraints to agricultural production and influence weed community dynamics, making the site ideal for evaluating the effects of agroecological management practices.

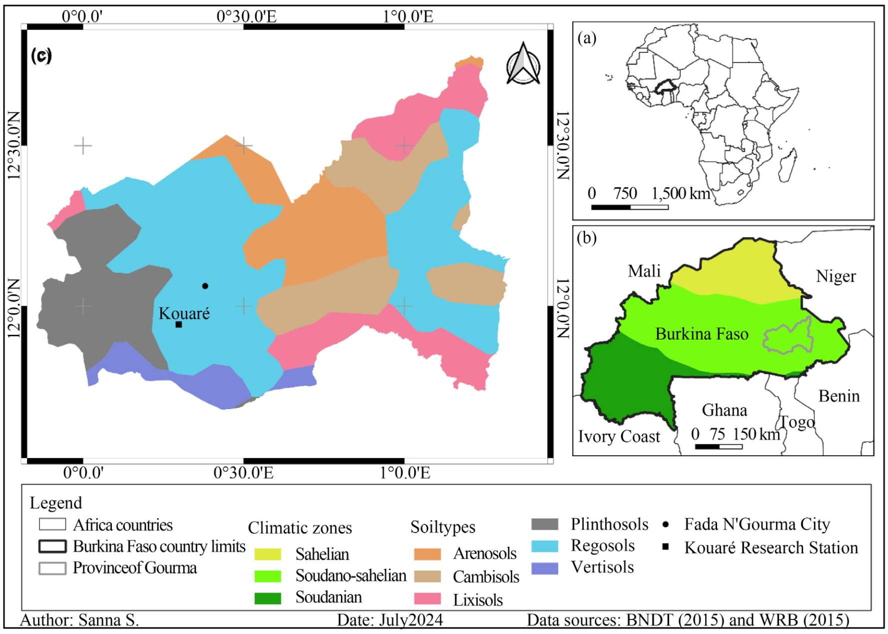

Figure 1. Study area. The map box (a) presents Burkina Faso country in the African continent; (b) presents the climatic zones of Burkina Faso and (c) the types of soil and the geolocation of the Research Station of Kouaré in the province of Gourma.

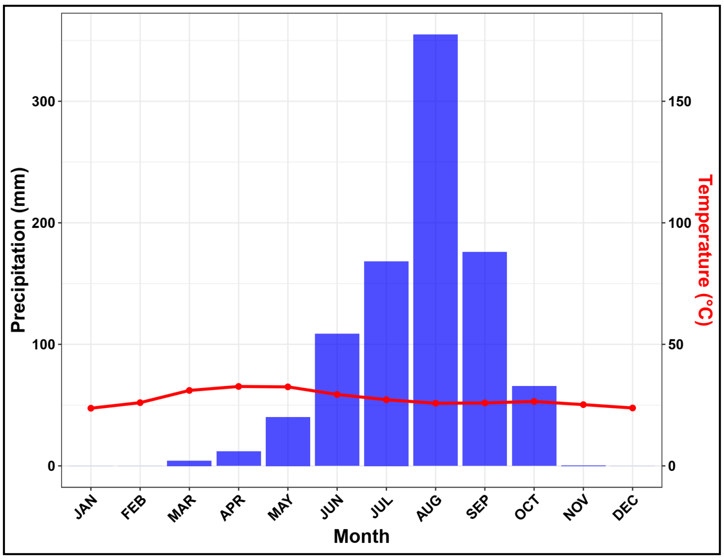

Figure 2. Ombrothermic Diagram (Average 2020–2021) of the study site. The data was obtained from the National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) Prediction of Worldwide Energy Resources (POWER) Project funded through the NASA Earth Science/Applied Science Program.

2.2. Plant Material

The plant material used in this study included a cereal species, sorghum and a legume species, represented by two different varieties of cowpea: Nerwaya and Moussa local. The sorghum variety used was ICSV 1049, which has a growth cycle of 110 to 115 days. The cowpea variety Nerwaya is characterized by a semi-erect growth habit and a short maturity period of about 70 days. Moussa local, another cowpea variety, has a cycle of 75 to 80 days and a creeping habit.

2.3. Experimental Design

A split-split plot design was used with complete randomization and three replications (**Figure 3** and **Figure 4**). The main plots were assigned to three tillage treatments (T):

T1: no-tillage before sowing.

T2: conventional tillage (mechanized plowing at a depth of 20 cm with tractor before sowing);

T3: ridge tillage.

The subplots were used for four cropping systems (C), involving different spatial arrangements of sorghum and cowpea:

C1: two rows of sorghum (128 plants × 4 = 512 plants) alternated with two rows of semi-erect cowpea (64 plants × 4 = 256 plants);

C2: two rows of sorghum (128 plants × 4 = 512 plants) alternated with two rows of creeping cowpea (64 plants × 4 = 256 plants);

C3: one row of sorghum (96 plants × 4 = 384 plants) alternated with one row of semi-erect cowpea (96 plants × 4 = 384 plants);

C4: one row of sorghum (96 plants × 4 = 384 plants) alternated with one row of creeping cowpea (96 plants × 4 = 384 plants).

The sub-subplots received four fertilization treatments (F):

F1: no fertilizer;

F2: compost at 2.5 t.ha^{-1};

F3: mineral fertilizer at 100 kg.ha^{-1} NPK and 50 kg.ha^{-1} urea;

F4: compost (2.5 t.ha^{-1}) + mineral fertilizer (100 kg.ha^{-1} NPK and 50 kg.ha^{-1} urea).

The compost used is based on cow dung. It had a neutral pH of 7.02 and contained 1.75% total nitrogen and 33.83% total carbon. The total phosphorus and total potassium contents were 2.83 g.kg^{-1} and 4.48 g.kg^{-1}, respectively. Each elementary plot measured 6 m × 4 m (24 m^2) and the soil is characterized by carbon content of 0.56%, a clay content of 11.80%, a silt content of 12.08% and a sand content of 76.12%. Sorghum and cowpea were sown in hills spaced 80 cm apart between rows and 40 cm between hills. Sowing was done in July for both experimental years. Thinning was performed 14 days after sowing (DAS) to retain only two plants per hill. NPK fertilizer (14-23-14) was applied using microdosing techniques 15 DAS. Urea (46% nitrogen) was applied at 45 DAS, also using microdosing.

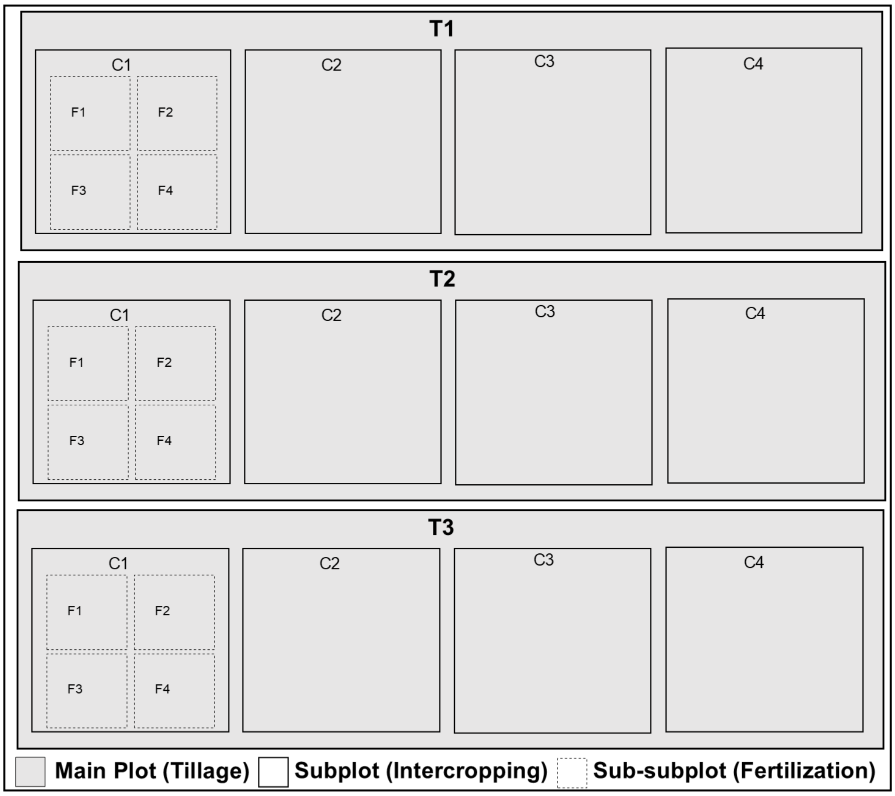

Figure 3. Partial representation of the experimental design.

Figure 4. Illustration of experimental plot with 2 rows of sorghum and 2 rows of cowpea.

2.4. Survey and Data Collection

Weed surveys were conducted in both 2020 and 2021, with two sampling periods per cropping season. The first inventory was performed 35 days after sowing (DAS) and the second at 65 DAS to ensure an exhaustive inventory of all weed species during crops cycles. The perimeter walk method [37] was employed to identify all emerged weed species. Species identification was based on direct morphological observation and confirmed using standard botanical references [38] [39]. Weed abundance was estimated using the density scale of Barralis (1976), while ground cover was assessed according to Marnotte's visual scale [40] [41]. Weed biomass was determined following each survey by randomly placing a 1 m^2 quadrat in each plot. All weeds within the quadrat were uprooted, bagged (**Figure 5**), oven-dried at 50˚C for 72 hours, and weighed to determine dry biomass.

Figure 5. Weed samples in bags.

2.5. Data Analysis

Data collected over the two cropping seasons were analysed using R program version 4.4 [42]. Canonical Correspondence Analysis (CCA) and Permutational Multivariate Analysis of Variance (PERMANOVA) were used to assess the influence of agricultural practices (tillage, intercropping systems, and fertilization) on weed community (**Table 1**). CCA was performed using weed community data matrix and agricultural practices as constraining matrix. Bray-Curtis distance was used for PERMANOVA with 999 permutations. Following CCA and PERMANOVA, the IndVal (Indicator Value) method described by Dufrêne and Legendre [43] was employed to identify characteristic weed species (Species almost exclusively associated with a given agricultural practice occur regularly and abundantly in that environment but are absent elsewhere. IndVal is an index used to identify indicator species in ecological analyses. It measures the association between a species and a specific group of sites. The IndVal statistic (shown in **Table 2**) ranges from 0 to 1, where 1 represents a perfect indicator species that occurs only within a particular group and is present at all sites in that group). The effects of agricultural practices on weed development, assessed through ground cover and biomass, were analysed using generalized linear models (GLMs) with a Gamma error distribution. This choice is justified by the fact that weed cover and biomass data are positive and continuous response variables. These are quantitative variables that can take an infinite number of values within a given interval, including fractional and decimal values. In the models, weed development (ground cover and biomass) is response variable and agricultural practices are explanatory variables. Tukey's

HSD test was further used to separate the means when GLMs revealed significant differences. The CCA and PERMANOVA were performed with the vegan package [44] and IndVal value was calculated with the *indicspecies* package [43]. All figures were performed with the *ggplot2* package [45], and the significance threshold for all statistical tests was set at 5%.

3. Results

3.1. Effect of Agricultural Practices on Weed Species Community

The tillage method is the main agricultural practice significantly influencing weed diversity (**Figure 6** and **Table 1**). No-tillage (T1) is characterized by the presence of five species (p-value < 0.05), among which *Cochlospermum tinctorium* Perr. Ex A. Rich. is the sole characteristic species. In conventional tillage (T2), *Mollugo cerviana* (L.) Ser. ex DC is the characteristic species. In contrast, ridge tillage (T3) supported eight weed species (p-value < 0.05) characterized by *Ceratotheca sesamoides* Endl., *Sida urens* L. and *Echinochloa colona* (L.) Link (**Table 2**).

Table 1. Main agricultural practices influencing weed community.

Variables	R^2	F-value	P-value	Significance
Tillage	0.007341	2.10683E + 14	0.037	Significant
Intercropping systems	0.002094	0.40072E−9	0.981	Not Significant
Fertilisation	0.002700	0.51668E−10	0.941	Not Significant
Residual	0.987863	-	-	

R^2, F-value and P-value provided by PERMANOVA analysis.

Table 2. Main characteristic species according to tillage modes.

Species	T1	T2	T3	Index	Stat	P-value
CEKSE	0	0	1	3	0.306	0.001
SIDUR	0	0	1	3	0.382	0.001
BOICH	0	1	1	6	0.307	0.001
TIUBA	1	1	0	4	0.325	0.001
ABMES	0	1	1	6	0.310	0.002
TEPBR	1	1	0	4	0.222	0.005
LUDLI	0	1	1	6	0.183	0.016
COKTI	1	0	0	1	0.169	0.023
AHQCO	0	1	1	6	0.236	0.025
MOLCE	0	1	0	2	0.144	0.031
WALAM	1	1	0	4	0.211	0.043
ECHCO	0	0	1	3	0.147	0.047
DEDBA	1	0	1	5	0.205	0.048

Index, stat and p-value provided by IndVal analysis. T1: no tillage before sowing; T2: conventional tillage; T3: ridge tillage. Abbreviations written in capital letters are taken from the EPPO Global Database. All abbreviations, and the corresponding list of species, are provided in **Appendix**.

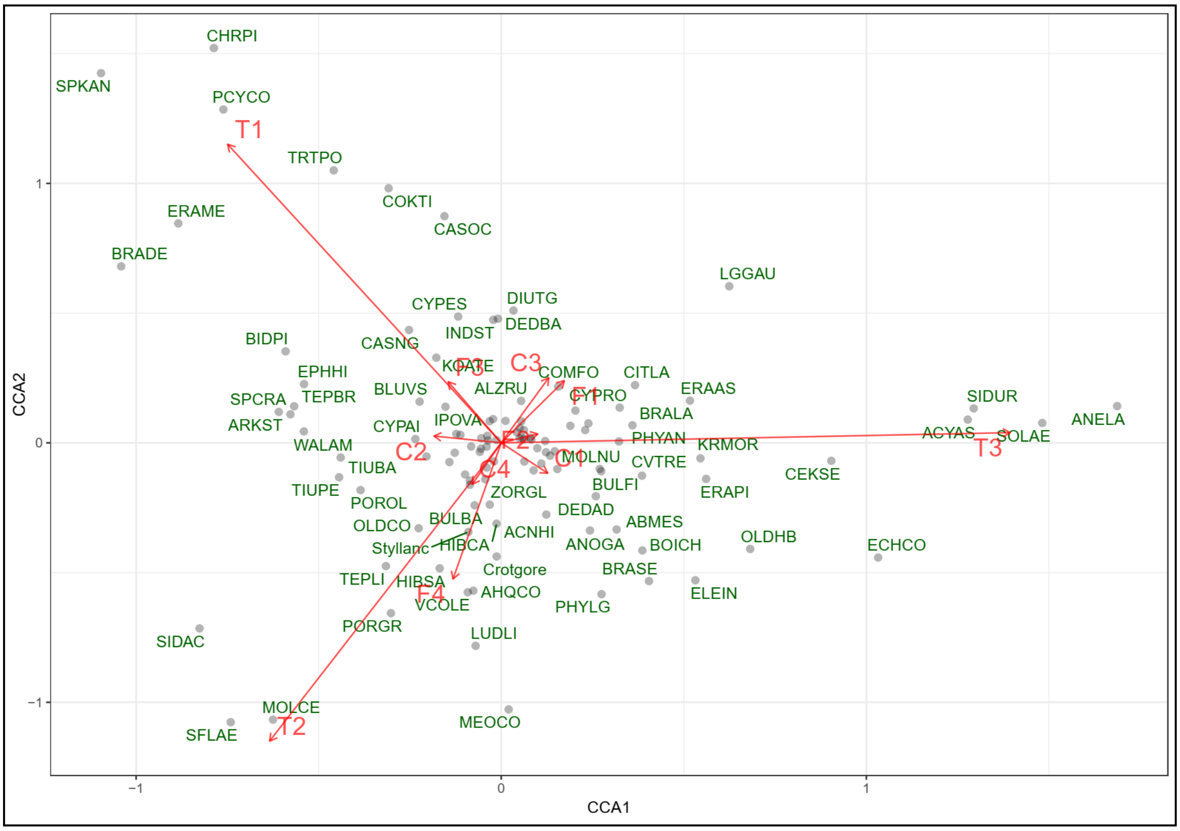

Figure 6. Relationship between weed species and agricultural practices.

Gray scatter plot and green color represent weed species community and red arrow represents agricultural practices. The length of arrow shows the influence of the variable on weed community.

The longer the arrow, the greater the influence, and the shorter the arrow, the less influence the variable has on the species. T1: no tillage before sowing; T2: conventional tillage; T3: ridges tillage ; C1: two rows of sorghum alternated with two rows of semi-erect cowpea; C2: two rows of sorghum alternated with two rows of creeping cowpea; C3: one row of sorghum alternated with one row of semi-erect cowpea; C4: one row of sorghum alternated with one row of creeping cowpea; F1: no fertilizer; F2: compost at 2.5 t.ha^{-1}; F3: mineral fertilizer at 100 kg.ha^{-1} NPK and 50 kg.ha^{-1} urea; F4: compost (2.5 t.ha^{-1}) + mineral fertilizer (100 kg.ha^{-1}NPK and 50 kg.ha^{-1} urea). Abbreviations written in capital letters are taken from the EPPO Global Database. Those written in lowercase do not currently have an EPPO code. All abbreviations, and the corresponding list of species, are provided in **Appendix**.

3.2. Effect of Agricultural Practices on Weed Ground Cover and Biomass

Weed ground cover was significantly influenced by fertilization and tillage practices, while total biomass was significantly affected only by tillage modes (Table 3). Mineral fertilization alone (F3) resulted in the highest weed cover (19.39 ±

15.57%; p-value < 0.05), representing increases of +35.49% compared to the non-fertilized treatment (F1) and +18.14% compared to compost application alone (F2) (**Figure 7**). Additionally, ridge tillage (T3) and no-tillage (T1) presented significantly lower weed cover compared to conventional tillage (T2), which showed the highest value (20.93 ± 15.05%). Compared to conventional tillage (T2), no-tillage (T1) and ridge tillage (T3) reduced weed cover by −17.73% and −37.17%, respectively (**Figure 7**). Finally, the lowest biomass (17.59 ± 13.70 $g.m^{-2}$) was observed with ridge tillage (T3), corresponding to reductions of −33.97% relative to no-tillage (T1; 26.64 ± 14.48 $g.m^{-2}$) and -32.29% compared to conventional tillage (T2; 25.98 ± 14.41 $g.m^{-2}$) (**Figure 8**).

Table 3. Main agricultural practices influencing weed ground cover and biomass.

	Ground cover			Biomass		
Variables	F-value	P-value	Significance	F-value	P-value	Significance
Tillage	16.985	6.86e-08	Significant	20.282	3.56e−09	Significant
Fertilization	3.119	0.0257	Significant	2.226	0.0652	Not significant
Intercropping	0.076	0.9728	Not significant	0.277	0.8417	Not significant

F-value and P-value provided by GLM analysis.

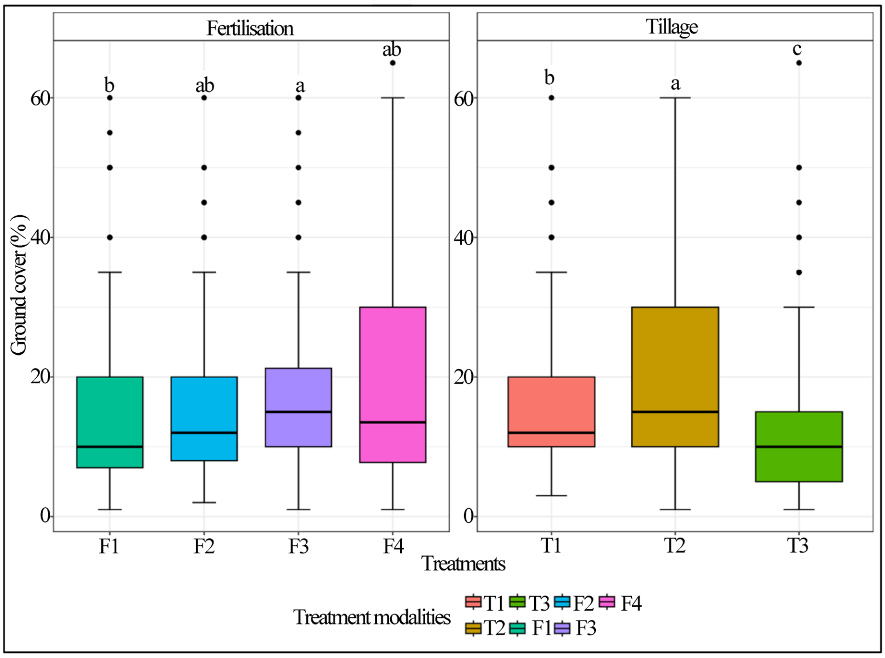

Figure 7. Effect of tillage and fertilization modes on weed ground cover. The boxplots with the same letter are not significantly different (p > 0.05) according to Tukey test. T1: no tillage before sowing; T2: conventional tillage; T3: ridge tillage. F1: no fertilizer; F2: compost at 2.5 $t.ha^{-1}$; F3: mineral fertilizer at 100 $kg.ha^{-1}$ NPK and 50 $kg.ha^{-1}$ urea; F4: compost (2.5 $t.ha^{-1}$) + mineral fertilizer (100 $kg.ha^{-1}$ NPK and 50 $kg.ha^{-1}$ urea). The number of experimental units (N) = 120 for fertilizer and 160 for tillage.

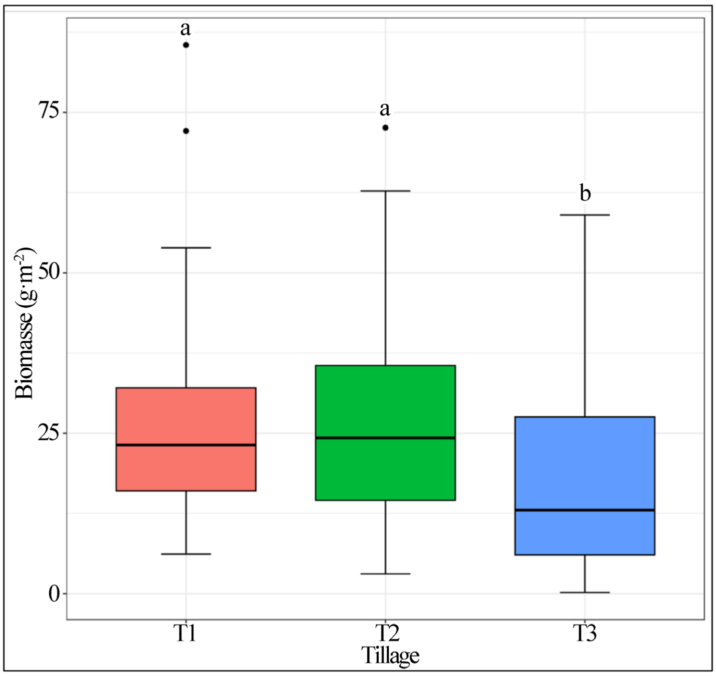

Figure 8. Effect of tillage on weed biomass. The boxplots with the same letter are not significantly different ($p > 0.05$) according to Tukey test. T1: no tillage before sowing; T2: conventional tillage; T3: ridge tillage. The number of experimental units (N) = 160 for tillage.

4. Discussion

4.1. Effect of Agricultural Practices on Weed Species Community

This study shows that tillage intensity is a major determinant of weed community composition in sorghum-cowpea intercropping systems within the Sudano-Sahelian zone. Each tillage system created distinct weed communities with characteristic species. No-tillage systems were characterized by *Cochlospermum tinctorium* as the sole indicator species, reflecting this West African savanna plant's adaptation to undisturbed soil conditions [46]-[48]. Conventional tillage favored *Mollugo cerviana*, typical of opportunistic annual species that exploit regularly disturbed habitats. Ridge tillage supported the most diverse community, characterized by *Ceratotheca sesamoides*, *Sida urens*, and *Echinochloa colona*, representing both broadleaf and grass functional groups [49] [50].

The observation of higher weed species richness under ridge tillage presents both opportunities and challenges for crop management [51]. Indeed, the diverse nature of the weed flora can, paradoxically, mitigate the pressure exerted by certain highly competitive species [52]. Additionally, some weeds can secrete allelopathic compounds that inhibit the germination or growth of more harmful competing species, contributing to a less destructive community balance for the crop [53].

However, higher species richness can complicate certain aspects of weed control such as resistance risk. The solution would be to regularly monitor weed composition and adapt strategies based on the evolving dominant species and their responses to interventions [54].

The differential responses reflect underlying seed bank dynamics and microhabitat heterogeneity. Indeed, no-tillage concentrates weed seeds near the soil surface, favoring established perennial species like *C. tinctorium* [55] [56]. Moreover, reduced soil disturbance in no-tillage systems limits vertical soil movement, thereby restricting the exposure of buried weed seeds to light and oxygen, key factors for germination [57] [58]. Conventional tillage distributes seeds throughout the tillage layer, creating optimal conditions for fast-germinating annuals. Ridge tillage creates the most heterogeneous environment with varied moisture, light, and soil conditions across ridge-furrow topography, supporting diverse ecological niches within the same field [51] [59].

These findings show that tillage system selection can strategically influence weed community composition. While ridge tillage supports higher characteristic species, diverse weed communities are often more stable and less prone to dominance by highly competitive single species [60] [61]. In West African semi-arid conditions, these tillage effects are mediated by environmental constraints including variable rainfall and nutrient-poor soils [62] [63]. The observed patterns reflect both direct tillage disturbance effects and indirect effects through altered soil water retention and organic matter dynamics, which influence weed-crop competition relationships.

Interestingly, variations in intercropping configurations did not significantly influence weed species diversity. This lack of effect may be attributed to similar canopy architecture and ground coverage among the intercropping treatments, which likely did not generate sufficient differences in microclimatic conditions to affect weed assemblages [64]-[66]. Indeed, previous studies have shown that more pronounced differences in crop spatial arrangement, such as strip intercropping versus intimately mixed configurations, are often needed to significantly alter weed suppression dynamics [57] [67].

Likewise, while fertilization increased crop growth, it had no significant effect on weed diversity, suggesting that nutrient enrichment mainly stimulates the growth of dominant weed species without substantially altering species composition [68] [69].

These observations align with the theory of disturbance-mediated community assembly, whereby the nature and intensity of disturbance act as ecological filters that select species with specific functional traits [70]-[72]. Conventional tillage, by enhancing disturbance, fosters trait divergence among weed species, whereas no-tillage favour species with conservative traits such as high seed production, dormancy, and shallow germination [73] [74]. While our study did not include direct measurement of functional traits or formal classification into functional groups, the observed shifts in species composition suggest changes in the functional profile of weed communities across tillage treatments. Managing tillage regimes may therefore represent a valuable tool for shaping the functional composition of weed communities and enhancing ecosystem services such as erosion control and pollinator support [12] [33] [72].

4.2. Effect of Agricultural Practices on Weed Ground Cover and Biomass

Regarding weed development, our results reveal that both tillage and fertilization practices significantly influenced weed ground cover, while weed biomass was mainly affected by tillage intensity. Mineral fertilization led to the highest weed cover, likely due to rapid nutrient availability promoting nitrophilous species with high growth rates and competitive ability [32] [75]. These results support prior research showing that fertilization enhances weed emergence and dominance, especially of fast-growing species [10] [76] [77].

Conversely, compost-based treatments, whether used alone or in combination with mineral fertilizer, reduced weed ground cover. This may be explained by the slower nutrient release of organic amendments and their positive effects on soil structure and microbial activity, which create less favorable conditions for the proliferation of opportunistic weeds [78]. Compost applications have also been linked to improved soil moisture retention and biological resilience, thereby suppressing weed growth and stabilizing weed community dynamics [11] [79] [80]. Tillage practices also influenced weed biomass, with conventional tillage supporting higher biomass than no-tillage and ridge tillage. Ridge tillage achieved the lowest biomass values, representing a reduction of over 30% compared to the other tillage methods. This may result from the creation of micro-topographical heterogeneity, which affects water distribution and soil temperature dynamics, thereby limiting favorable conditions for weed establishment [81] [82] [83].

These findings underscore the value of ridge tillage as a component of integrated weed management strategies. Ridge tillage not only reduces weed pressure but also supports agroecological goals by minimizing external inputs and potentially contributing to system sustainability [4] [83] [84]. When combined with organic amendments, ridge tillage offers a synergistic pathway for sustainable intensification by suppressing weeds, improving soil health, and potentially supporting a more balanced weed community structure. However, this assertion requires further investigation through dedicated trait-based analyses and functional diversity measurements [85] [86].

5. Conclusions

This study provides compelling evidence that tillage intensity and fertilization mode are the primary drivers of weed community structure and development in sorghum-cowpea intercropping systems under Sudano-Sahelian conditions. Ridge tillage supports the highest characteristic species richness but achieved the greatest reduction in weed biomass and ground cover, highlighting the role of soil disturbance in shaping weed dynamics. Moreover, the use of compost, whether alone or in combination with mineral fertilizers, was associated with lower weed proliferation compared to mineral fertilization alone, which tended to favor nitrophilous and fast-growing species. These findings emphasize the potential of agroecological practices to enhance weed regulation through ecological processes rather than chemical inputs. By promoting weed suppression while potentially supporting weed species diversity, practices such as ridge tillage and organic amendments align with the goals of sustainable intensification, particularly for smallholder farming systems constrained by labor and input access.

From an applied perspective, this research supports a paradigm shift towards integrated weed management strategies that combine ridge tillage with organic fertilization. Such strategies can reduce the labour burden associated with manual weeding and may contribute to long-term soil health and productivity, though long-term studies would be needed to verify these potential benefits. Moreover, our study's limitations include its short duration (two growing seasons) and focus on taxonomic rather than functional diversity metrics. Further research should explore long-term weed seedbank dynamics and interactions with soil biota to refine weed management recommendations under varying agroecological contexts across West Africa.

Data Availability

The data are available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Abbreviations

The following abbreviations are used in this manuscript.

GLMs	Generalized Linear Models
CCA	Canonical Correspondence Analysis
PERMANOVA	Permutational Multivariate Analysis of Variance
HSD	Honestly Significant Difference

Appendix

Table A1. Species inventoried.

Species abbreviated name	*Species whole name*
ABMES	*Abelmoschus esculentus* (*L.*) *Moench* [*cult.*]
ACCSE	*Acalypha segetalis Müll.Arg.*
ACNHI	*Acanthospermum hispidum DC.*
ACYAS	*Achyranthes aspera L.*
ACYFA	*Achyranthes sp*
AHQCO	*Alchornea cordifolia* (*Schumach. & Thonn.*) *Müll.Arg.*
ALZOV	*Alysicarpus ovalifolius* (*Schumach.*) *J.Léonard*
ALZRU	*Alysicarpus rugosus* (*Willd.*) *DC.*
ANOGA	*Andropogon gayanus Kunth*
ANELA	*Aneilema lanceolatum Benth.*
ARKST	*Aristida stipoides Lam.*
CVNLO	*Astraea lobata* (*L.*) *Klotzsch*
BIDPI	*Bidens pilosa L.*
LGGAU	*Pseudoconyza viscosa* (*Mill.*) *D'Arcy*
BRADE	*Brachiaria deflexa* (*Schumach.*) *C.E.Hubb. ex Robyns*
BRALA	*Brachiaria lata* (*Schumach.*) *C. E.Hubbard*
BRASE	*Brachiaria sp*
BRADP	*Brachiaria villosa* (*Lam.*) *A.Camus*
BULBA	*Bulbostylis barbata* (*Rottb.*) *C.B.Clarke*
BULHI	*Bulbostylis hispidula* (*Vahl*) *R.W.Haines*
BULFI	*Bulbostylis sp*
CEOTR	*Celosia trigyna L.*
CEKSE	*Ceratotheca sesamoides Endl.*
CASNG	*Cassia nigricans Vahl*
Champrat	*Chamaecrista pratensis* (*R.Vig.*) *Du Puy*
CHRPI	*Chloris pilosa Schum.*
CITLA	*Citrullus lanatus* (*Thunb.*) *Matsum. & Nakai*

Continued

CLEMO	*Cleome monophylla L.*
CLEVI	*Cleome viscosa L.*
COKTI	*Cochlospermum tinctorium Perr. Ex A. Rich.*
COMBE	*Commelina benghalensis L.*
COMFO	*Commelina forskalaei Vahl.*
COMSU	*Commelina subulata* Roth
CRGOL	*Corchorus olitorius* L.
CRGTD	*Corchorus tridens* L.
KRMOR	*Crinum ornatum* (L.f. ex Aiton) Bury
Crotgore	*Crotalaria goreensis* Guill.& Perr.
CVTRE	*Crotalaria retusa* L.
Crotsene	*Crotalaria senegalensis* (Pers.) Bacle ex DC.
CVTTR	*Crotalaria trichotoma* Bojer
CUMME	*Cucumis melo* L. [cult.]
CYGSH	*Cyperus sp*
CYPAI	*Cyperus amabilis* Vahl
CYPRN	*Cyperus reduncus* Hochst. ex Boeckeler
CYPES	*Cyperus esculentus* Linn.
CYPRO	*Cyperus rotundus* L.
DTTAE	*Dactyloctenium aegyptium* (L.) Willd.
DEDAD	*Desmodium adscendens* (Sw.) DC.
DEDBA	*Desmodium barbatum* (L.) Benth.
DEDDI	*Desmodium dichotomum* (Willdenow) de Candolle
DEDTO	*Desmodium sp*
PEPBI	*Dicliptera paniculata* (Forssk.) I.Darbysh.
DMATO	*Dicoma tomentosa* Cass.
DIGHO	*Digitaria horizontalis* Willd.
DIUTG	*Dioscorea togoensis* R.Knuth
ECHCO	*Echinochloa colona* (L.) Link
ELEIN	*Eleusine indica* (L.) Gaertn.
ERAAS	*Eragrostis aspera* (Jacq.) Nees
ERACI	*Eragrostis ciliaris* (L.) R.Br.
ERAME	*Eragrostis cilianensis* (All.) Vignolo ex Janch.
ERAPI	*Eragrostis pilosa* (L.) P.Beauv.
ERATM	*Eragrostis tremula* Hochst. ex Steud.
EPHHI	*Euphorbia hirta* L.
GOMCE	*Gomphrena celosioides* Mart.

Continued

HIBCA	*Hibiscus cannabinus* L. [cult.]
HIBSA	*Hibiscus sabdariffa* L. [cult.]
HIBSS	*Hibiscus sp*
HPYSS	*Hyptis sp*
HPYSP	*Hyptis spicigera* Lam.
INDHI	*Indigofera hirsuta* L.
INDST	*Indigofera stenophylla* Guill. & Perr.
IPOCS	*Ipomoea coscinosperma* Hochst. ex Choisy
IPOER	*Ipomoea eriocarpa* R.Br.
IPOVA	*Ipomoea vagans* Baker
KOATE	*Kohautia tenuis* (Bowdich) Mabb.
KYLPU	*Kyllinga pumila* Michx.
KYLSQ	*Kyllinga squamulata* Thonn. ex Vahl
LEVMA	*Leucas martinicensis* (Jacq.) R.Br.
LUDLI	*Ludwigia hyssopifolia* (G. Don.) Exell
MAPSQ	*Mariscus squarrosus* Steud.
MEOCO	*Melochia corchorifolia* Linn.
MTCVI	*Mitracarpus hirtus* (L.) Dc.
MOLCE	*Mollugo cerviana* (L.) Ser. ex DC
MOLNU	*Mollugo nudicaulis* Lam.
OCICA	*Ocimum americanum* L.
OLDCO	*Oldenlandia corymbosa* Linn.
OLDHB	*Oldenlandia herbacea* (L.) Roxb.
PESPE	*Pennisetum pedicellatum* Trin.
VCOLE	*Pentanema indicum* (L.) Y.Ling
PYLAM	*Phyllanthus amarus* Schumach. & Thonn.
PHYAN	*Physalis angulata* L.
PHYLG	*Physalis lagascae* Roem. & Schult.
PHYSS	*Physalis sp*
PCYCO	*Polycarpaea corymbosa* (L) Lam.
PORGR	*Portulaca grandiflora* Hook.
POROL	*Portulaca oleracea* L.
BLUVS	*Pseudoconyza viscosa* (Mill.) D'Arcy
CASNG	*Cassia nigricans* Vahl
CASOB	*Senna obtusifolia* L.
CASOC	*Senna occidentalis* (L.) Link
SETPU	*Setaria pumila* (Poir.) Roem. & Schult.

Continued

SIDAC	*Sida acuta* Burm.f.
SIDBA	*Sida alba* L.
SIDRH	*Sida rhombifolia* L.
SIDUR	*Sida urens* L.
SFLAE	*Siphonochilus aethiopicus* (Schweinnf.) B.L.Burtt
SOLAE	*Solanum nigrum* L.
SOLNI	*Solanum nigrum* L.
BOICH	*Spermacoce chaetocephala* DC.
SPCRA	*Spermacoce radiata* (DC.) Sieber ex Hiern
BOISY	*Spermacoce stachydea* DC.
SPKAN	*Spigelia anthelmia* L.
STRGE	*Striga gesnerioides* (Willd.) Vatke
STRHE	*Striga hermonthica* (Delile) Benth.
Styllanc	*Stylochaeton lancifolius* Kotschy & Peyr.
TEPBR	*Tephrosia bracteolata* Guill. & Perr.
TEPLI	*Tephrosia linearis* (Willd.) Pers.
TRTPO	*Trianthema portulacastrum* L.
TIUPE	*Triumfetta pentandra* A.Rich.
TIUBA	*Triumfetta rhomboidea* Jacq.
VCOSS	*Vicoa sp*
WALAM	*Walteria indica* L.
ZORGL	*Zornia glochidiata* Rchb. ex DC.