EFFECT OF SEED RATE AND PHOSPHORUS FERTILIZERS ON WEED SPECIES COMPOSITION, DENSITY, AND DIVERSITY IN SESAME VARIETIES IN SUDAN SAVANNAH OF NIGERIA

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Abstract

A field experiment was conducted during the 2023 and 2024 cropping seasons in Jigawa State Sudan Savannah Zone of Nigeria to determine the effect of seed rate and phosphorus fertilizer on weed species composition, density, and diversity in sesame (Sesamum indicum L.) variety. The experiment was a factorial laid out in a randomized complete block design with three replications. Treatments consisted of three seed rates (3, 4, and 5 kg ha^{-1}), and three phosphorus levels (0, 20, and 40 kg P_2O_5 ha^{-1}). Data were collected on weed species composition, weed density, weed dry biomass, and diversity indices. Results revealed that, higher seed rates and phosphorus fertilization significantly reduced weed density and dry biomass, while enhancing crop competitiveness. Shannon-Wiener and Simpson diversity indices decreased with increased seed rate and phosphorus application, indicating reduced weed diversity. The crop consistently suppressed weeds more effectively. The interaction between seed rate and phosphorus application significantly influenced weed composition and sesame yield. It was concluded that the application of 40 kg P_2O_5 ha^{-1} combined with 5 kg ha^{-1} seed rate optimizes sesame growth while minimizing weed interference.

Keywords: *Sesame, Phosphorus fertilizer, Weed diversity and Seed rate.*

Introduction

Sesame (*Sesamum indicum* L.) is an important oilseed crop cultivated extensively in tropical and subtropical regions. Nigeria ranks among the top producers in Africa, contributing significantly to export earnings. However, sesame production in the Sudan Savannah zone is constrained by weed infestation, nutrient depletion, and low input use. Weeds compete aggressively with sesame for nutrients, moisture, and sunlight, often reducing yield by 30–60% when unmanaged (Adewumi *et al*., 2021). Phosphorus plays a critical role in root establishment and crop vigor, enhancing the plant's competitive ability against weeds (Aliyu and Umar, 2020). Seed rates also influence crop canopy closure and weed suppression (Yakubu *et al*., 2022). Despite previous studies on weed management, limited information exists on the combined influence of seed rate and phosphorus fertilization on weed composition and diversity in sesame production under the Sudan Savannah conditions of Nigeria. This study, therefore, aimed to evaluate the effect of seed rate and phosphorus fertilizers on weed species composition, density, and diversity in two sesame varieties.

Materials and Methods

The field trials were conducted during the 2023 and 2024 cropping seasons at Teaching and Research farm of Sule Lamido University Kafin Hausa Jigawa State, located in the Sudan Savannah Ecological Zone of Nigeria (latitude 13°02′N, longitude 9°36′E). The soil type is sandy loam, low in organic matter, and slightly acidic. The experiment was a 2 × 3 × 3 factorial arrangement in a Randomized Complete Block Design with three replications.

Sesame variety used as test crops under three seed rates (3, 4, and 5 Kg ha^{-1}) and three phosphorus fertilizer levels (0, 20, and 40 kg P_2O_5 ha^{-1}).

Phosphorus was applied as single superphosphate at planting. Standard agronomic practices were followed. Data were collected on weed species composition, density (plants m^{-2}), and dry biomass (g m^{-2}) at 6 weeks after sowing (WAS) and at harvest. Diversity indices were computed using the Shannon-Wiener (H′) and Simpson's (D) formulas. Data were subjected to analysis of variance (ANOVA), and treatment means were compared using LSD at 5% probability level.

Results

Weed Species List and Frequency:

The effect of the treatments on weed relative frequency at the experimental site before harvest is presented in Table 1. The table presents a summary of weed species observed across the two experiment years, categorized into three major groups based on their plant types of Dicotyledon weeds (broadleaf weeds), Monocotyledon weeds (grasses) and Sedges.

Among the dicots, *Ipomoea asarifolia* was the most dominant, followed by *Phyllanthus amarus* and *Cassia tora*. *Ageratum conyzoides* was the least frequent while highest relative frequency (11.84%) was recorded for *Ipomoea asarifolia*, making it the most dominant weed in the overall research field.

The Poaceae family dominates the monocots, with *Pennisetum pedicellatum* and *Brachiaria alata* being the most frequent grass weeds. Poaceae (grasses) had the highest number of species recorded, showing that grasses were the most diverse group in the experiment area. while *Cyperus rotundus* is the most prevalent sedge, indicating its strong adaptability and persistence in the study area. The lowest relative frequency (5.26%) was observed with *Ageratum conyzoides* and *Imperita cylindrica*. *Cyperus rotundus* was the most prevalent sedge, indicating its strong adaptability and persistence in the study area.

Effect of Phosphorus (P_2O_5) Levels on Weed Density:

The effect of phosphorus levels on weed density is shown in Table 2. As the phosphorus level increased from 0 to 40 Kg P_2O_5 ha^{-1}, the mean weed density decreased from 45.2 to 35.1 plants m^{-2}. This shows a negative relationship between.

Table 1: Weed species list and frequency across the experiment years

Weed Species (botanical name)	Family	Frequency	Relative Frequency (%)
Dicotyledon weeds			
Amaranthus spinosis (Linn.)	Amaranthaceae	5	6.58
Ageratum conyzoides (Linn.)	Compositae	4	5.26
Phyllanthus amarus (Schum & Thonn.)	Phylanthaceae	7	9.21
Ipomoea asarifolia (Desr.)	Convolvulaceae	9	11.84
Cassia tora	Fabaceae	7	9.21
Monocotyledon weeds			
Imperita cylidrica (Linn.)	Poaceae	4	5.26
Pennisetum pedicellatum (Trin.)	Poaceae	8	10.53
Digitaria horizontali (Willd.)	Poaceae	6	7.89
Cenchrus biflorus (Roxb.)	Poaceae	5	6.58
Brachiria alata (Schumach.)	Poaceae	8	10.53
Sedges			
Kyllinga squamulatus	Cyperaceae	5	6.58
Cyperus rotundus (Linn.)	Cyperaceae	8	10.53

Table 2: Mean weed density (plants m^{-2}) at 6 weeks after sowing (WAS) by treatment

Variety	Seed rate (kg ha^{-1})	P level (kg P_2O_5 ha^{-1})	Mean weed density (plants m^{-2})	SE	N
V1	3	0	45.2	3.1	4
V1	4	20	38.6	2.8	4
V1	5	40	35.1	2.4	4

Phosphorus application and weed density, higher phosphorus levels were associated with fewer weeds. The magnitude of reduction from 45.2 to 35.1 plants m^{-2} represents approximately a 22% decrease in weed density. This suggests that phosphorus fertilization may improve crop competitiveness, possibly by enhancing crop vigor and canopy spread, which suppresses weed growth.

The consistency and reliability indicate that, the standard errors (SE = 2.4 – 3.1) are relatively small compared to the mean values, indicating consistent results across replications (N = 4). This strengthens the reliability of the observed trend of the overall inference that for sesame at a seed rate of 3 Kg ha^{-1}, increasing phosphorus application reduced weed infestation at 6 weeks after sowing (WAS). This implies that optimal phosphorus nutrition not only benefits the crop but also aids in early weed suppression.

3.3 Weed Dry Biomass

Table 4 shows the effect of seed rate and phosphorus (P) fertilizer levels on weed dry biomass for a sesame crop variety. Weed dry biomass (g/m^2) indicates how much weed material (dry weight) was present at harvest, which indicates that, higher values mean more weed growth in experimental plots. However, SE (Standard Error) shows the variability or precision of the mean value which also indicates that, smaller SE means the result is more reliable. Weed biomass decreased steadily as both seed rate and phosphorus level increased, From 250.3 g/m^2 to 190.6 g/m^2 and to 140.2 g/m^2. This shows that, denser planting and better nutrient availability helped the crop suppress weed growth effectively. The reduction of 110.1 g/m^2 (from 250.3 to 140.2) represents a 44% decline in weed biomass across treatments.

Higher seed rates promote faster canopy closure, which reduces light availability for weeds, thereby suppressing their growth. Phosphorus application enhances crop vigor and competitiveness, further limiting weed biomass. The combination of high seed rate (5 Kg/ha) and high phosphorus level (40 Kg P_2O_5/ha) is the most effective treatment for weed suppression in this experiment.

Table 3: Weed dry biomass (g m^{-2}) at harvest, mean ± SE

Variety	Seed rate (kg ha^{-1})	P level (kg P_2O_5 ha^{-1})	Weed biomass (g m^{-2})	SE	N
V1	3	0	250.3	18.5	4
V1	4	20	190.6	15.8	4
V1	5	40	140.2	12.3	4

3.4 Weed Diversity

Table 4 shows how weed diversity changed under different treatments of seed rate and phosphorus (P) fertilizer level for sesame crop. The result indicates some key diversity measures such as *Species richness* (S): number of different weed species present, *Shannon-Wiener index* (H′): overall diversity, considering both the number of species and how evenly individuals are distributed among them and that of Higher H′ = greater diversity which include *Evenness* (E): this is how evenly individual weeds are distributed among species were

when closer to 1 indicates it is more even distribution and *Simpson's index* (D): measures dominance; higher D means higher diversity and lower dominance by a few species.

The results indicates that Species richness (S) decreased from 12 to 9 and then 7 as seed rate and phosphorus level increased. While Shannon-Wiener (H′) and Evenness (E) also declined, indicating that both weed variety and balance among species were reduced. Simpson's D decreased from 0.78 to 0.59, confirming that diversity dropped and a few weed species became dominant under the most competitive conditions. These findings showed that, at low seed rate and no phosphorus (3 kg/ha, 0 P), weeds were more diverse and abundant, as the crop provided little competition. While at medium seed rate and phosphorus (4 Kg/ha, 20 P), weed diversity moderately decreased, suggesting the crop began to suppress weaker weed species and at high seed rate and phosphorus (5 Kg/ha, 40 P), weed diversity was lowest, indicating that dense, well-nourished crops effectively suppressed weeds, allowing only a few hardy species to survive.

Table 4: Diversity indices (Shannon-Wiener H' and Simpson's D) per treatment

Variety	Seed rate	P level	Species richness (S)	Shannon-Wiener H'	Evenness (E)	Simpson's D
V1	3	0	12	1.89	0.68	0.78
V1	4	20	9	1.56	0.65	0.71
V1	5	40	7	1.22	0.61	0.59

4. Discussion

The results of this study clearly indicate that both seed rate and phosphorus fertilizer levels significantly influenced weed species composition, weed density, and diversity across sesame varieties in the Sudan Savannah of Nigeria. The observed variations in weed population dynamics under different treatments can be attributed to changes in the competitive balance between the sesame crop and the weed flora.

This finding aligns with the reports of Udom and Okon (2023) and Ghosh and Verma (2019), who found that dense crop stands significantly suppressed annual grasses and broadleaf weeds by limiting light and space availability. Similarly, Adekpe *et al.* (2021) reported that increased plant density reduced the number of *Amaranthus spinosus* and *Digitaria horizontali* plants in sesame fields, confirming that crop geometry is a critical component of cultural weed management.

However, excessively high seed rates can sometimes lead to intra-specific competition among crop plants, potentially reducing seed yield per plant. In this study, the 5 kg ha^{-1} rate provided the most effective weed suppression without visible negative effects on sesame growth, suggesting it is an optimal balance for this ecological zone.

Application of phosphorus (P) fertilizer significantly influenced weed growth and composition. The treatments that received higher P levels (20 and 40 kg P_2O_5 ha^{-1}) exhibited lower weed biomass and diversity compared to the zero-P plots. This can be explained by the enhanced early vigor of sesame plants resulting from adequate phosphorus nutrition, which improved root development and nutrient uptake efficiency. Vigorous crop growth in turn led to early canopy formation, effectively suppressing weeds.

This observation agrees with Jaliya *et al.* (2020) and FAO (2022), who reported that phosphorus application enhances early crop establishment and canopy expansion, reducing light interception by weeds. Phosphorus is essential for energy transfer (ATP synthesis) and root elongation, allowing sesame plants to compete more effectively for soil nutrients and moisture.

Nevertheless, some nutrient-responsive weed species such as *Amaranthus* and *Cyperus* spp. also thrived under moderate P supply in less competitive plots. This highlights the need to balance fertilizer rates with crop density to maximize crop advantage while minimizing weed proliferation.

The interaction between seed rate and phosphorus levels showed a synergistic effect on weed suppression. The combination of high seed rate (5 kg ha^{-1}) and high phosphorus (40 kg P_2O_5 ha^{-1}) recorded the lowest weed biomass and diversity indices (H′ and D). This suggests that integrating cultural (seed rate) and nutritional (fertilizer) strategies can effectively reduce weed pressure without sole reliance on herbicides.

The observed reduction in Shannon-Wiener (H′) and Simpson's (D) indices indicates a decline in both weed species richness and evenness. According to Shetty et al. (2018) and Ekeleme *et al.* (2014), such reduction reflects successful weed management, as the dominance of a few surviving species under intensive management conditions points to a less competitive weed community.

The results corroborate findings from other semi-arid regions, where increased seeding density combined with balanced fertilization reduced the abundance of annual weeds such as *Pennisetum pedicellatum*, *Digitaria horizontali*, and *Cyperus rotundus*. The results confirm that weed community composition is dynamic and responds strongly to management intensity and resource distribution within the cropping system.

The present study demonstrates that weed suppression in sesame can be enhanced through agronomic manipulation rather than exclusive dependence on chemical control. High seed rate and adequate phosphorus application improve the crop's natural ability to compete, reducing the need for herbicide use and lowering production costs and environmental impact.

These findings support the Integrated Weed Management (IWM) concept advocated by Akobundu (2016), which emphasizes combining cultural, mechanical, and chemical methods for sustainable weed control. Adopting higher seed rates and optimal phosphorus fertilization not only minimizes weed interference but also enhances soil cover, conserves moisture, and reduces erosion in the fragile Sudan Savannah environment.

The decline in weed biomass observed in this study is comparable to that reported by Ayeni *et al.* (2017), who recorded a 50–70% reduction in weed dry weight under dense sorghum and sesame populations. Similarly, Okafor *et al.* (2020) observed that vigorous crop growth resulting from balanced nutrient application suppressed late-emerging weeds and reduced weed seed bank accumulation. This suggests that cultural and fertility-based weed control methods are reliable, cost-effective, and environmentally sustainable options for smallholder farmers in the region.

Further more, higher seed rates significantly reduced weed density and biomass through early canopy closure. Phosphorus fertilization enhanced sesame vigor and competitiveness, further suppressing weeds. The interaction of high seed rate and high phosphorus level produced the lowest weed diversity indices, confirming strong crop dominance for suppression weeds in sesame-based cropping systems in the Sudan Savannah.

5. Conclusion and Recommendations

The study clearly demonstrates that increasing seed rate and phosphorus application significantly suppresses weeds in sesame production by reducing weed biomass, density, and species diversity. The combination of 5 kg ha^{-1} seed rate and 40 kg P_2O_5 ha^{-1} provided the highest weed suppression, promoting better crop competitiveness and environmental sustainability. Adoption of these practices can reduce herbicide dependence and improve productivity of sesame in the Sudan Savannah of Nigeria.

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