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Research Article

Effect of Weed Control Methods on the Performance of Maize (*Zea Mays* L.) Varieties in the Northern Guinea and Sudan Savanna Zones of Kebbi State

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Abstract

Two field trials were conducted during the 2025 wet season at the Teaching and Research Farms of Abdullahi Fodio University of Science and Technology, Aliero and Kebbi Agricultural Development Authority (KARDA) Research Farm, Yauri, Kebbi State, Nigeria (Latitude 10.7870° N and Longitude 4.8070° E). To evaluated the response of maize varieties to different weed control treatments under Savanna agro-ecological zones of Kebbi State. The treatments consisted of three maize varieties (SAMMAZ-9, SAMMAZ-51, and SAMMAZ-59) and five weed control treatments, namely: Application of (2,4-D at 500 ml ha⁻¹, Atrazine at 375 g ha⁻¹, 2,4-D at 500 ml ha⁻¹ + atrazine at 375 g ha⁻¹, Hoe weeding@3&6 WAS, and Weedy check). The experiments were laid out in a Randomized Complete Block Design, arranged in a factorial combination with three replications. The results of the study showed that SAMMAZ-9 consistently produced superior vegetative growth, recording higher plant height higher harvest index, and superior grain yield, although its performance was statistically comparable with SAMMAZ-51 for several growth and yield components in Aliero and Yauri except for grain yield at Yauri where SAMMAZ-51 recorded higher yield than all other varieties. Weed control treatments significantly affected the growth and yield parameters. The combined application of 2,4-D at 500 ml ha⁻¹ + atrazine at 375 g ha⁻¹ consistently produced the lowest weed dry weight, higher seed weight, grain yield and highest harvest index at both locations. The untreated weedy check consistently recorded the poorest performance because of severe weed competition throughout the growing season. Based on the results obtained from these trials, it can be concluded that application of 2,4-D at 500 ml ha⁻¹ + atrazine at 375 g ha⁻¹ inconjunction with SAMMAZ-51 resulted in effective weed control and produced the highest grain yield at both locations.

Keywords: *Atrazine, SAMMAZ, Cob, Yield, Weed.*

INTRODUCTION

Maize (*Zea mays* L.), is a popular crop that belongs to the Poaceae family. It is a warm weather crop, that prefer temperature between 18-35 ^{0C} for optimum growth, and is grown under wide range of soil types with good drainage. Loam and medium soils with pH of 6.0-7.0 are preferred (FAOSTAT, 2021). Globally, maize occupies a total cultivated land of 197 mega hectares, including areas in sub-Saharan Africa (SSA), Asia and Latin America, with a yield of 1134 metric tons per year and a productivity of 5.75 tons per hectare. In Nigeria, maize is cultivated across almost all agro-ecological zones, including the humid forest areas, the derived savanna, and the northern Guinea savanna. The crop is highly valued because it adapts well to different environmental conditions and has the potential to produce relatively high yields (FAOSTAT, 2021). Each portion of the crop has monetary value: the seeds, shoot, head and kernel which can be synthesized to produce a large diversity of food and non-food products. Corn is consumed in developed nations as a second-cycle product in meat, eggs, and dairy products. The crop is eaten directly in third world nations and is staple nutrition for around 200 million people (Anonymous, 2003). Despite the importance of maize in Nigeria, its productivity remains below potential due to challenges such as poor soil fertility, pests and diseases, irregular rainfall, and especially weed infestation. Weeds compete with maize for nutrients, water, sunlight, and space, particularly during the early growth stages, leading to reduced crop growth and lower yields if not effectively controlled (Okezie-Akobundu and Ekeleme, 2002). Farmers commonly use manual weeding, mechanical cultivation, or herbicides, but each method has limitations. Manual hoe weeding is labour-intensive, costly, and often delayed, while herbicide use is constrained by high costs, limited technical knowledge, and health and environmental concerns (Shrestha *et al.,* 2019; Landao *et al*., 2021). Therefore, identifying sustainable and effective weed management practices is essential for improving maize productivity, particularly in the Northern Guinea and Sudan Savanna zones of Kebbi State.

MATERIALS AND METHODS

Experimental Sites

Field experiments were conducted simultaneously during the 2025 wet season at the Research Farm of Abdullahi Fodio University of Science and Technology, Aliero (AFUSTA), Kebbi State, Nigeria (Latitude 13°01′ N and Longitude 5°15′ E), and the Kebbi Agricultural Development Authority (KARDA) Research Farm, Yauri, Kebbi State, Nigeria (Latitude 10.7870° N and Longitude 4.8070° E), located approximately 350 m above sea level within the Sudan Savanna agro-ecological zone of Nigeria. The treatments consisted of a factorial combination of five weed control methods (2,4-D at 1000 mL ha^{-1} applied at 3 and 6 Weeks After Sowing (WAS), Atrazine at 750 g ha^{-1} applied at 3 and 6 WAS, 2,4-D at 500 mL ha^{-1} + Atrazine at 375 g ha^{-1} applied at 3 WAS, Hoe weeding at 3 and 6 WAS and Weedy check) and three maize varieties. SAMMAZ 9, SAMMAZ 51 and SAMMAZ 59. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

The experimental fields were ploughed and harrowed to obtain a fine tilth before ridging at 75 cm spacing. The fields were subsequently be demarcated into plots according to the experimental layout. A 0.5 m alley was maintained between plots, while two ridges were separate adjacent replications. NPK fertilizer (15:15:15) was applied at the rate of 350 kg ha^{-1} at 4–6 Weeks after Sowing (WAS) following the recommended agronomic practice. The application was done in split application. The post-emergence herbicides (2,4-D and Atrazine) was applied according to treatment specifications at 3 and/or 6 WAS. Herbicides were applied using a CP3 knapsack sprayer fitted with a green deflector nozzle calibrated to deliver 250 L ha^{-1} of spray solution at a pressure of 2.1 kg cm^{-2}. Spraying were carried out in the morning under calm weather conditions to minimize spray drift. Manual hoe weeding was carried out at 3 and 6 WAS in plots assigned to the hoe-weeding treatment. Harvesting was carried out manually when the maize plants attain physiological maturity, indicated by yellowish-brown husks and hardened grains. Harvested cobs were sun-dried, weighed, shelled, cleaned, and the grains stored for yield determination. Weed data on weed flora, weed cover score, weed dry weight and weed control efficiency were collected at harvest. Growth and yield data such as plant height, shoot dry weight, cob weight, cob diameter, 100 seed weight and grain yield were also collected. And subjected to Analysis of Variance (ANOVA) using the Statistical Analysis System (SAS) software. Treatment means that differ significantly at the 5% probability level were separated using Duncan's Multiple Range Test (DMRT).

RESULTS

Weed Flora associated with Maize

The common weed species found at the experimental sites during the course of the study and their level of infestation at Aliero and Yauri are presented in Table 1. The dominant weed species at the experimental site at both locations initially were grasses such as *Dactyloctenium aegyptium* (linn.) P. Beauv, *Rottboelia cochinchinensis* (Lour.) Clayton*, Digitaria horizontalis* Wild.*, Cynodon dactylon* (Linn.) Pers., *Eleusine indica* Gertin*.* and the sedges included *Cyperus rotundus* Linn. and *C. difformis* Linn. As the trial proceeded, the grasses were followed by broad-leaved weeds such as *Ageratum conyzoides* Linn.*, Boerhavia diffusa* L.*, Commelina benghalensis* L. and *Physalis angulate* Linn.

Weed cover score, dry weight and weed control efficiency (%)

Table 2 presents the effects of weed control treatments and maize varieties on weed cover score, weed dry weight, and weed control efficiency during the 2025 wet season at Aliero and Yauri. There was significant difference among the maize varieties on weed dry weight and weed control efficiency at both Aliero and Yauri, whereas weed cover score did not differ significantly among the varieties. At Aliero, weed cover score ranged from 3.40 to 3.50 among the three maize varieties. SAMMAZ-9 recorded the lowest weed cover score while both SAMMAZ-51 and SAMMAZ-59 recorded higher and similar values. Similarly, at Yauri, weed cover score ranged from 4.60 to 4.80, with SAMMAZ-9 producing the lowest value while SAMMAZ-51 recorded the highest. At Aliero, SAMMAZ-9 recorded the lowest weed dry weight, which was significantly lower than those of SAMMAZ-51 and SAMMAZ-59. Likewise, at Yauri, SAMMAZ-9 maintained the lowest weed dry weight, whereas SAMMAZ-51 and SAMMAZ-59 recorded significantly higher values, respectively. Similarly, weed control efficiency varied significantly among the maize varieties. At Aliero, SAMMAZ-59 recorded the highest weed control efficiency, followed closely by SAMMAZ-51, while SAMMAZ-9 recorded the lowest value. At Yauri, however, SAMMAZ-59 again recorded the highest weed control efficiency, followed by SAMMAZ-51, whereas SAMMAZ-9 had the lowest efficiency.

The influence of weed control treatments on weed cover score was highly significant at both locations. At Aliero, the untreated weedy check recorded the highest weed cover score. This was followed by 2,4-D applied at 1000 ml ha^{-1} at 3 and 6 weeks after sowing, atrazine applied at 750 g ha^{-1} recorded a lower weed cover score, while hoe weeding and the combined application of 2,4-D at 500 ml ha^{-1} plus atrazine at 375 g ha^{-1} recorded even lower values, respectively. Likewise a similar trend were observed at Yauri. On other hand the weed dry weight was also affected by weed control treatments in both locations. At Aliero, the untreated control produced the highest weed dry weight. Application of 2,4-D alone reduced weed dry weight, while atrazine alone further reduced weed biomass. Hoe weeding produced a comparable reduction. However, the combination of 2,4-D and atrazine drastically reduced weed dry weight. Similar observations were made at Yauri where the untreated control recorded the highest weed biomass, whereas the herbicide mixture reduced weed biomass to only. Weed control efficiency exhibited even clearer treatment differences. At Aliero, the combined application of 2,4-D + atrazine recorded the highest weed control efficiency. Hoe weeding ranked second, followed by atrazine alone and 2,4-D alone. As expected, the untreated control recorded 0% weed control efficiency. A similar pattern was observed at Yauri where the herbicide mixture achieved higher weed control efficiency, greatly exceeding atrazine alone, hoe weeding, and 2,4-D alone. The interaction between maize varieties and weed control treatments was not significant for all measured parameters.

Table 1: Common weed species found at the experimental sites and their level of infestation at Aliero and Yauri during 2025 wet season.

Weed species	Level of infestation	
Grasses	**Aliero**	**Yauri**
Cynodon dactylon (Linn.) Pers.	*	**
Chloris pilosa Schumach	*	*
Dactyloctenium aegyptium (Linn.) P. Beauv.	**	*
Digitaria horizontalis. Willd	*	*
Eleusine indica Gaertn	*	*
Broad leaved		
Ageratum conyzoides Linn.	***	*
Ipomea involucrata P. Beauv.	*	-
Synedrella nodiflora Gaentn	*	-
Boerhavia diffusa L.	*	*
Physalis angulata Linn.	*	*
Commelina benghalensis L.	*	*
Sedges		
Cyperus difformis linn.	*	*
Cyperus rotundus Linn.	*	**

*** High infestation (60 – 100%)
** Moderate infestation (40 – 59%)
* Low infestation (1 – 39%)

Table 2: effects of weed control treatments on weed cover score, weed dry weight and weed control efficiency of maize varieties during 2025 wet season at Aliero and Yauri

Treatment	Weed Cover Score	Weed weight (gm^{-2})	Weed control efficiency (%)	Weed Cover Score	Weed weight (gm^{-2})	Weed control efficiency (%)
	Aliero			Yauri		
Variety						
SAMMAZ-9	3.40	8.83b	53.60b	4.60	6.07b	60.69b
SAMMAZ-51	3.50	10.39a	56.79a	4.80	8.63a	64.10a
SAMMAZ-59	3.50	10.11a	57.82a	4.73	8.36a	66.46a
SE±	**0.141**	**0.167**	**0.187**	**0.159**	**0.193**	**0.180**
Weed Control						
2,4-D@1000ml/ha @ 3 and 6 WAS	5.28b	9.00b	48.70d	4.33b	9.18b	54.04c
Atrazine@750g/ha @ 3	4.02c	8.01c	57.52c	3.42c	8.74bc	69.31b

and 6 WAS						
2,4-D@500ml/ha + Atrazine@375g/ha @ 3 WAS	3.41cd	3.63d	95.14a	3.00c	4.88d	93.28a
Hoe weeding @ 3 and 6 WAS	3.60d	8.22c	73.45b	2.00d	6.33c	67.62b
Weedy check	6.30a	10.81a	0.00e	5.50a	11.23a	0.00d
SE±	**0.179**	**0.115**	**0.216**	**0.158**	**0.241**	**0.271**
Interaction						
N x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment are not significantly different at 5% using DMRT.*= Significant at 5%, NS= not significant.

Seed Weight, Grain Yield and Harvest Index

Table 3 Present the effects of weed control treatments on 100-seed weight, grain yield, and harvest index of maize varieties during the 2025 wet season at Aliero and Yauri. The results revealed that maize varieties significantly influenced 100-seed weight, grain yield, and harvest index at both locations. In both locations, SAMMAZ-9 produced the highest 100-seed weight, although it was statistically similar to SAMMAZ-51. SAMMAZ-59 recorded the lowest seed weight. Grain yield also differed significantly among the maize varieties. At Aliero, SAMMAZ-9 recorded the highest grain yield, followed closely by SAMMAZ-51. SAMMAZ-59 produced the lowest yield. Although SAMMAZ-51 was statistically comparable to SAMMAZ-9, both varieties significantly outperformed SAMMAZ-59. However, a similar trend was observed on harvest index in both locations.

The weed control treatments were also significant on 100 seed weight, grain yield and harvest index. in both Aliero and Yauri, the combined application of 2,4-D at 500 ml ha^{-1} + atrazine at 375 g ha^{-1} consistently produced the highest 100-seed weight grain yield and harvest. This value was significantly greater than that of 2,4-D alone but statistically comparable with atrazine alone and hoe weeding. The untreated weedy check recorded the lowest mean values.

Harvest index also responded significantly to weed management. At Aliero, all weed control treatments produced relatively high harvest indices ranging from 37.09% to 39.97%, whereas the untreated control recorded the lower value. The highest harvest index was obtained under 2,4-D alone, although it was statistically similar to the combined herbicide treatment, atrazine alone and hoe weeding. These findings indicate that all effective weed control treatments improved assimilate partitioning compared with the untreated control. At Yauri, the combined herbicide treatment again produced the highest harvest indices, followed closely by atrazine alone, hoe weeding, and 2,4-D alone. The untreated control recorded a significantly lower harvest index. This result demonstrates that weed competition not only reduced grain yield but also impaired the efficiency with which maize plants partitioned dry matter to the grains.

Table Effects of weed control treatments on 100seed weight, grain yield and harvest index of maize varieties during 2025 wet season at Aliero and Yauri

Treatment	**100 Seed weight (g)**	**Grain yield (t/ha)**	**Harvest index (%)**	**100 Seed weight (g)**	**Grain yield (t/ha)**	**Harvest index (%)**
	Aliero			**Yauri**		
Variety						
SAMMAZ-9	29.40a	3.91a	39.33a	32.13a	3.58ab	39.33a
SAMMAZ-51	27.80a	3.77ab	38.62a	30.38a	4.29a	38.90a
SAMMAZ-59	25.76b	3.00b	33.74b	28.16b	2.80b	36.05b
SE±	**0.754**	**0.031**	**1.053**	**0.825**	**0.035**	**1.613**
Weed Control						
2,4-D@1000ml/ha @ 3 and 6 WAS	27.91b	3.05c	39.97a	30.51b	3.32b	37.81a
Atrazine@750g/ha @ 3 and 6 WAS	28.91a	3.19b	37.09a	31.60a	3.56b	38.75a
2,4-D@500ml/ha + Atrazine@375g/ha @ 3 WAS	30.70a	4.10a	38.69a	33.56a	4.69a	39.23a

Hoe weeding @ 3 and 6 WAS	28.66a	3.95ab	37.35a	31.33a	4.17ab	38.18a
Weedy check	18.33c	0.49d	18.53b	20.03c	0.55c	24.23c
SE±	**0.806**	**0.024**	**1.888**	**0.881**	**0.028**	**1.245**
Interaction						
N x V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column in each treatment are not significantly different at 5% using DMRT.*= Significant at 5%, NS= not significant.

DISCUSSION

Varietal Response

The present study demonstrated that maize varieties differed significantly in most of the vegetative growth, reproductive, and yield parameters evaluated during the 2025 wet season at Aliero and Yauri. The significant varietal differences observed for plant height, shoot dry weight, leaf area index, days to 50% tasselling and silking, cob characteristics, 100-seed weight, grain yield, and harvest index indicate that the three maize varieties differed considerably in their genetic potential for growth and productivity. The superior vegetative performance of SAMMAZ-9 may be attributed to its inherent genetic ability to efficiently utilize available growth resources, including nutrients, moisture, solar radiation, and growing space. This agrees with the findings of Garko, *et al*. (2023), who reported significant varietal differences in plant height, biomass accumulation, and canopy development among improved maize varieties grown under rain-fed conditions in Nigeria. The superiority of SAMMAZ-9 with respect to cob weight, cob length, kernel weight, and harvest index over other varieties further confirms that the variety efficiently partitioned assimilates from vegetative organs to reproductive structures. The findings corroborate those of Machiani *et al*. (2023), who reported that maize varieties exhibiting superior harvest index generally produced heavier cobs and higher grain yield because of improved assimilate partitioning. Likewise, Liu *et al*. (2024) observed that modern maize cultivars with high harvest indices exhibited greater efficiency in converting photosynthates into economic yield than older cultivars, resulting in significant improvements in grain productivity.

The superior performance of SAMMAZ-51 at Yauri indicates that the variety may possess greater adaptability to the specific environmental conditions prevailing at that location. This observation agrees with the findings of Ahmad. (2024), who reported that genotype × environment interaction significantly influences the productivity of improved maize varieties in the Northern Guinea and Sudan Savanna zones of Nigeria. The authors observed that certain varieties may exhibit superior performance in one location but perform only moderately in another because of differences in climatic conditions, soil fertility, and rainfall distribution. Similar conclusions were reached by FAO (2023), which emphasized that varietal adaptation remains one of the most important determinants of crop productivity under varying agro-ecological conditions.

Effect of weed control treatments on weed infestations

The result of these findings indicates that the post-emergence application of 2,4-D at 500 ml/ha+ Atrazine@ 375g/ha provided better weed control and produced lower weed cover score and weed dry weight than all other weed control treatments and weedy check. The possible reason could be that there was good weed control in the 2,4-D at 500 ml/ha+ Atrazine@ 375g/ha applied plot. Likewise, the increase in weed control efficiency observed as a result of faster absorption of 2,4-D at 500 ml/ha+ Atrazine@ 375g/ha by the weeds in a plot is not surprising because there was fast absorption of the herbicide by the weeds, which results in a drastic reduction of weed cover score and dry weight. This work corroborates with Arvadiya, (2012). Who reported higher weed control efficiency in herbicide treated plot over untreated plot. The higher weed dry weight and weed cover score observed in weedy check plots resulted from intense competition for limited environmental resources, which resulted in a reduction in crop performance.

Effect of weed control treatments on the growth of maize

The superior performance of maize on establishment counts as a result of the post-emergence application of 2,4-D at 500 ml/ha+ Atrazine@ 375g/ha over other weed control treatments in both locations, could be a result of efficient control of weeds which makes growth factors such as moisture, nutrients, and sunlight more available for the crops. In contrast, the weedy check had the least establishment counts with poor growth. The lower maize stands with poor growth observed in the weedy check could be associated with the aggressive nature of weeds competing for scarce growth resources, which led to low crop performance and the loss of some crop stands. The positive role of weed control treatments observed could have been the reason for improved performance of maize with regards to plant height, leaf area index and dry matter production compared with weedy check. This is because weed infestation throughout the lifecycle of crop in unweeded plots resulted to competition for environmental factors such as sunlight, nutrients, moisture etc. between weeds and the crop which significantly depressed these growth parameters. Chikoye, *et al*. (2022) observed that good weed control reduces competition for environmental resources which enable the plant to develop more and produce longer leaves resulting to efficient light interception for increase in dry matter accumulation.

Similar findings were by Patel *et al.* (2012) who observed that good weed control reduces competition for environmental resources, which enables the plant to develop more and produce longer leaves resulting in an efficient light interception for a rise in dry matter production. The lower performance of maize in the weedy check observed in both locations could be attributed to competition between weeds and crop plants for limited available moisture and mineral nutrients, so plants could not produce more leaves to conserve the available moisture for critical growth stages. Gupta *et al*. (2021) reported intense weed competition in the weedy check causes a significant reduction in growth characteristics such as shoot dry matter accumulation and crop leaf area index.

Effect of weed control treatments on yield and yield attributes of maize

The grain yield of maize is the ultimate product of various yield components and is the expression and association of several plants' growth components. The application of weed control treatments resulted in a significant and positive variation of grain yield and yield attributes of maize in locations. This could be mainly attributed to effective weed control in the herbicide-treated plots and weed suppression in the later stage of the life cycle which in turn, has a positive and direct effect on the growth and development of the crop, better light interception and production and translocation of assimilates, resulting in an increase in grain yield. Likewise, the positive response of most of the yield components such as cob length, cob weight, 100-grain weight and grain yield to weed control treatments in both locations could also be attributed to effective weed control management and the ability for weed control measures applied to control weeds beyond the level that can have a harmful effect on the performance of maize crops. This result concurs with that of Imoloame *et al.* (2018). They reported a significant increase in cob length, diameter, number of seeds per cob, cob weight, and maize seed yield in herbicide-treated plots over the weedy check.

CONCLUSION

The study showed that maize varieties differed significantly in growth and yield, with SAMMAZ-9 and SAMMAZ-5 performing better. Effective weed management, particularly the combined application of 2,4-D at 500 ml ha^{-1} + atrazine at 375 g ha^{-1}, significantly improved growth and grain yield across both locations.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

i. SAMMAZ-9 is recommended for cultivation in Aliero, Sudan Savanna agro-ecological zone because of its superior vegetative growth, high biomass production, favourable yield components, and consistently high grain yield, while at Yauri SAMMAZ-59 recorded high yield than all other varieties
ii. Farmers should adopt the combined application of 2,4-D at 500 ml ha^{-1} plus atrazine at 375 g ha^{-1} for effective control of broadleaf and grassy weeds in maize production, as this treatment consistently produced the highest grain yield at both locations.
iii. Additional research should investigate the economic viability (cost-benefit analysis) of the different weed control treatments to determine the most profitable weed management strategy for smallholder maize farmers.

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