



PERFORMANCE OF MAIZE (*Zea mays* L.) AS INFLUENCE BY GOAT MANURE RATES AND WEED MANAGEMENT STRATEGIES IN SOUTHERN GUINEA SAVANNA, NIGERIA

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ABSTRACT: Field study was conducted during 2020 and 2021 cropping seasons at the Teaching and Research Farm of Ibrahim Badamasi Babangida University, Lapai at Southern, Guinea Savanna, Nigeria. The aim of the study was to evaluate the performance of maize under different goat manure rates and weed management strategies. Treatments consisted of two factors; goat manure rates (0, 5, 10, and 15t ha⁻¹) and five weed management strategies [weeding once at 3 weeks after sowing (WAS); weeding twice at 3 and 6 WAS; weeding thrice at 3, 6 and 9 WAS; weed free, and Weedy check] laid out in Randomized Complete Block Design (RCBD) with three replications. Data were collected on weed density, weed control efficiency, growth and yield characters such as plant height, number of leaves per plant, leaf area, leaf area index, dry cob weight and grain yield. Data were analyzed using analysis of variance using GenStat Package version 17 and means were compared using Duncan's New Multiple Range Test at 5 % probability level. The goat manure was relatively high in organic matter, N and P compared with K, Ca and Mg. The results showed that the most dominant of weed species were the broadleaves such as the *Hyptis suaveolens* and *Tridax procumbens*. An increasing goat manure at 15 t ha⁻¹ in combination with weed free treatment improved growth parameters such as plant stand count, plant height, and leaf area, reducing the detrimental impact of weeds in the field. Similarly, higher grains and yield components were reported in plots treated with 15 t ha⁻¹ of goat manure in addition to weed free. Oba supper 11maize variety with the application of 15 t ha⁻¹ of goat manure and weed free is recommended for farmers in the research region

Keywords: Maize, weeds, goat manure, management, strategies, rates

INTRODUCTION

Maize (*Zea mays* L.) is an annual crop that belong to the family Poaceae which emanated from the tribe Maydeae (Udoh and Ndon 2016). Maize was said to have originated in America through the domestication of the wild grass teosante (*Zea mexicana*), and then spread and adapted to various environmental conditions throughout the world. Maize has played a significant part in worldwide agri-food systems since its introduction some 9,000 years ago (Erenstein *et al.*, 2022). Maize is a global staple crop and important source of feed and industrial products in high-income countries, but it also offers food and nutritional security in the world's poorest regions, including Sub-Saharan Africa, Asia, and Latin America. It is the world's most important crop in terms of cultivation area, after wheat and rice (Osagie and Eka, 1998). The crop accounts for 40% of cereal output in Sub-Saharan Africa, with more than 80% being used as food. It provides at least 30%- of total calorie consumption, with daily intake ranging from 52 to 450 g (Prasanna *et al.*, 2021). Maize consumption in Latin America ranges between 50 and 267 grams per person per day (Poole *et al.*, 2020). The global maize area (for dry grain) amounts to 197 M ha, including substantive areas in sub-

Saharan Africa (SSA), Asia and Latin America (FAOStat, 2021). The United States of America and Brazil in 2022 accounted for 39% of global maize production, of which China recorded the second-largest producer, accounting for 24% (FAO, 2023). Nigeria produced approximately 10.2 million tons of maize from 4.8 million hectares, making it Africa's largest producer in 2018 (Kamara *et al.* 2020). Maize is used as food for humans and livestock in various parts of the world in the form of *palp* (Ogi), *Monsa*, *Abari*, and *Agidi*, as well as livestock feeds, . It is also used as an industrial material in the manufacture of several commodities such as flour, starch, oil, alcohol, and other edible products (Adeyeye *et al.*, 2017).

Various factors contributed to the decline in agricultural production, with weeds being the most significant cause of reduced maize output (Nahere *et al.*, 2018). Despite the economic importance of maize in Nigeria, yields are significantly lower than expected due to a variety of problems such as weed infestation, low soil fertility, and labor availability (Imoloame, 2017). Weed infestation in maize has caused yield losses ranging from 60 to 80% (Lagoke *et al.*, 1998). Breeders and agronomists have conducted a variety of research efforts to develop technologies, including the breeding of high yielding varieties that are resistant to drought, diseases, low nitrogen, and *Striga* infestation in order to achieve better maize yield (Kamara *et al.*, 2014). The use of synthetic or chemical fertilizers is effective and convenient, but it is harmful to the environment and causes significant soil damage when applied repeatedly. However, organic manure improves nitrogen availability, soil structure, water retention, and soil organic matter while posing fewer environmental risks (Ancheng and Xi, 1994). According to Talip and Sison (2017), goat dung is an organic fertilizer that may be used in crop development. Goat dung contains more nitrogen from urine collected in the animal's droppings (Phipps, 2013), as well as phosphoric acid (Rowell and Hadad, 2004). The consistent use of goat manure increases organic matter in soils and improves soil structure, thereby improving water-holding capacity, aeration, friability, and drainage (Rowell and Hadad, 2004).

Weed control is the most challenging and resource-intensive aspect of grain production, particularly maize, if it is not carried out at the appropriate time or using the correct approach (Adeyemi *et al.*, 2019). Weed control in maize is essential for increased crop development and productivity. Weeds typically compete with crops for nutrients, sunlight, space, and water. Manual weeding is the most popular method of weed control in Nigeria. A significantly greater yield was reported in a two-trial employing both hoe weeding methods mixed with herbicide combination, and the results demonstrated that hoe weeding was superior to the other weed control strategies used in the study in terms of maize grain production (Adeyemi *et al.*, 2019).

Therefore, the goal of this study was to investigate the performance of maize as influenced by goat manure rates and weed management strategies that would result in effective and efficient weed control as well as increased maize grain yield.

MATERIALS AND METHODS

Site location

The study was conducted during the 2020 and 2021 rainy seasons at the Ibrahim Badamasi Babangida University Teaching and Research Farm in Lapai, Niger State. Lapai is located between 9°1°40'N and 9°4°10'N on the Equator, and 6°32°30'E and 6°34°10'E on the Greenwich Meridian.

Land clearing and preparation

Prior to land preparation in both seasons, soil samples were collected at random from the experimental field at depths ranging from 0 to 15cm using a soil auger and used to determine the physic-chemical properties of the soil in the experimental site. The samples were combined to produce a composite sample. The sample was air dried, crushed, and sieved through a 2.0 mm screen to determine the pH in water, total nitrogen, organic carbon, accessible phosphorus, calcium, magnesium, potassium, sodium, and exchangeable cations using standard laboratory procedures as described by Walkley and Blak (1984). Also, goat dropping was collected for the determination of its composition.

Treatment and experimental design

The treatments consisted of a factorial combination of four goat manure rates (0, 5, 10, and 15 t ha⁻¹) and five manual hoe weed management strategies at [weeding once at 3 weeks after sowing (WAS); weeding twice at 3 and 6 WAS;

weeding thrice at 3, 6 and 9 WAS; weed free, and Weedy check (control)]. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental field was cleared of vegetation, then ploughed and ridged. The experimental plots were partitioned into 3×3 m (9 m^2), each with four ridges separated by 0.5 m and 1 m path ways and alley, respectively. Maize (Oba Supper 11) was sown at spacing of 75×25 cm, with two seeds per hole which was thinned to one per stand at 2 WAS.

Goat manure application

The goat droppings were dried and pulverized before been incorporated into the experimental plots two weeks before sowing. Application of goat dropping was done based on the treatments allocated to each experimental plot.

Pests and diseases control and harvesting

There was no incidence of pests or diseases infestation that attained economic importance in the experimental field during the cropping seasons. Therefore, no control measures were applied. Harvesting was done manually at its maturity. The cobs were plucked, dehusked and then weighed. The cobs were dried, threshed and winnowed to obtained clean grain seeds.

Data collection and analysis

Data from the net plots were collected on weed, growth and yield metrics such as plant stand count, plant height, number of leaves per plant, leaf area per plant, leaf area index per plant, dry cob weight per ha, 100 seed weight per ha, and grain yield per ha. Weed samples were collected by inserting a 1 m^2 quadrat in each plot before weeding based on treatment. The collected weeds were identified using a Handbook of West African Weeds (Akobundu *et al.*, 2016). Data were examined using GENSTATE (17th edition version). Means were compared using Duncan's multiple range test (DMRT) at 5 % probability level.

RESULTS

Soil and goat manure sample analysis:

Table 1 presents results on the soil physical and chemical properties of the experimental site during 2020 and 2021 cropping seasons. Based on the rating of NSPFS (2005), the soil was sandy loam with moderate acidity (pH of 5.5) in 2020 to slightly neutral (pH 5.8) in 2021. Low organic carbon, total nitrogen, and phosphorus in both years. Continuous cropping on the same piece of land could be the reason that lead to low organic carbon, total nitrogen, and phosphorus in the experimental site. The exchangeable bases were high in K^{+2} and Na^{+2} , while Ca^{+2} was low and moderate Mg^{+2} . The soil had higher cation exchange capacity (CEC) of 73.04 in 2020 and 74.8 C mol kg^{-1} in 2021. Low soil nutrient status, especially cation exchange capacity, was linked to increased farming activities in the area. This conclusion was consistent with the findings of Noma *et al.* (2011), who noted that ongoing cultivation techniques could be followed by crop residue removal, potentially exposing the soil to degradation. Esu and Lombin (1987) also reported that, vertisols are productive soils, which are non saline and mildly to slightly sodic; they are high in basic cationic nutrients, but very low in organic matter, nitrogen phosphorous and copper. For the goat manure, the results revealed slightly neutral pH (6.35), high organic carbon, accessible phosphorus, total nitrogen, and calcium content, but low Mg^{+2} , K^{+2} , and Na^{+2} (Table 1).

Table 1: Soil and goat manure sample analysis during 2020 and 2021 rainy seasons

	Physical properties				Chemical properties				Exchangeable base (Cmol kg^{-1})				
	Sand %	Clay %	Silt %	Textural class	pH in water	OC %	Total N. %	Avail. P. Mg kg^{-1}	Ca	Mg	K	Na	CEC
Soil analysis 2020	77.6	10.8	11.6	Sandy loam	5.5	4.63	1.91	0.87	1.6	0.33	8.81	1.89	73.04
Soil analysis 2021	76.5	11.2	12.3	"	5.8	4.75	1.80	0.94	1.36	1.33	8.71	1.93	74.8
Goat manure 2020	-	-	-	-	6.2	21.13	1.52	1.19	3.74	0.61	0.23	0.16	-
Goat manure 2021	-	-	-	-	6.5	21.05	1.47	1.24	3.85	0.55	0.25	0.12	-

Weed compositions in the experimental field during the 2020 and 2021 rainy seasons

Weed of various classes such as grasses, broadleaves and sedges were identified during the 2020 and 2021 cropping seasons. Twenty three (23) weed species belonging to thirteen (13) families were collected and identified in both years. The experimental field was highly infested with six weed species such as *Boerhavia erecta*, *Digitaria horizontalis*, *Brachiaria lata*, *Cleome viscosa*, *Hyptis suaveolens*, and *Tridax procumbens*, though *Tridax procumbens* had the highest infestations in 2020, while *Hyptis suaveolens* and *Tridax procumbens* showed a similar trend in 2021. The substantial infestation of broadleaf weeds in the experimental location may be due to their rapid growth and capacity to shade other weed species. Karaye *et al.* (2018) had a similar result, identifying 15 broadleaves out of 26 weed species. Fabunmi *et al.* (2018) and Adeyemi *et al.* (2014) found that *Tridax procumbens* and *Digitaria horizontalis* were the dominant species. Higher infestation of particular weed species may be due to the agricultural technique used by farmers (Adeyemi *et al.*, 2014). *Tridax procumbens* is noted for producing a large number of seeds and being easily adaptable to varied climatic conditions, resulting in a bigger infestation of a location (Fabunmi *et al.*, 2018).

Weed density and weed control efficiency

Table 2 present results on weed density and weed control efficiency as influenced by goat manure rates and weeding regimes during the 2020 and 2021 rainy seasons. Across years, increase in goat manure resulted in significant decrease in weed density. Control treatments significantly produced greater weed density compared to the other manure rates. The decrease in weed density could be due to increasing soil nutrient of goat manure leading to vigorous plant growth and subsequent shading of the crop resulting to weed suppression. The research conducted by Lira-Saldivar *et al.* (2004) showed that different amounts of goat manure had a clear impact on the number of weeds. For example, the control plot (0 kg ha⁻¹) had 58.25 plants m², while 20 kg ha⁻¹ and 40 kg ha⁻¹ had an average of 32.0 and 22.0 plants m⁻¹ respectively. This shows that goat manure had an inhibitory effect on the weeds population. In 2020 and 2021, weeding thrice (3, 6 and 9 WAS) recorded the least weed density compared to the other weeding regimes. Getting rid of weeds at the right time seems to make it easier for plants to get to resources, which increases plant height, biomass, branches and improves shredding for better growth and weed suppression. This result corroborate the study of Ali *et al.* (2024) who reported that higher total leaf area index (LAI) in MSI increased canopy cover, which suppressed the weed infestation due to excessive shading and reduced light penetration.

Table 2: Effect of Goat Manure and Weed management Strategies on Weed density and Weed Control Efficiency on the performance of maize

	Weed density	Weed density	Weed control efficiency	Weed control efficiency
Treatments	2020	2021	2020	2021
Goat manure rates				
0 t/ha	48.43a	48.37a	46.17b	47.30a
5 t/ha	43.27b	37.50bc	52.75a	34.96c
10 t/ha	37.53c	36.77c	40.30c	45.32a
15 t/ha	36.13c	38.93b	32.11d	40.94b
SE±	0.640	0.594	1.52	1.244
Weed management				
Weeding once at 3 WAS	57.04b	58.75b	26.98d	27.63d
Weeding twice at 3 and 6 WAS	28.79c	33.04c	47.48c	40.16c
Weeding thrice at 3, 6 and 9 WAS	20.38d	17.12d	62.17b	61.00b
Weed free	11.42e	10.75e	77.53a	81.39a
Weedy check	89.08a	82.29a	0.00e	0.00e
SE±	0.716	0.664	1.701	1.391
Interaction				
GM × WM	**	**	**	NS

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT. NS = not significant, *= significant at 5% level, **= highly significant at 1% level

Weed control efficiency was significantly higher in 2020 for 5 t/ha and 0 or 10 t/ha in 2021 which gave better control efficiency compared to the other treatments. This finding suggests that a vigorous crop can outcompete weeds for resources such as light, water, and nutrients, successfully inhibiting their growth through organic manure application, such as goat manure. In this way, improved maize growth owing to manure may lead to less weed impact. Mashingaidze *et al.* (2020) observed similar findings, revealing that the biomass of weeds within the row decreased in the broadcast treatment as fertilizer application increased. Weed free produced the highest weed control efficiency in both years, which was closely followed by weeding thrice at 3, 6 and 9 WAS which was better than weeding once and twice across years. Highest weed control efficiency in this study could be as a result of multiple applications of the treatments at shorter intervals which generally lead to the highest efficiency. The weedy check recorded the lowest weed control efficiency. Adewale *et al.* (2019) reported that weedy check plots in their research on weed control efficiency of management practices of Sesame consistently produced significantly lower weed control efficiency than all other treatments in all the locations of the experiment. There was significant interaction of goat manure rates with weed management strategies on weed density in 2020 and 2021 and significant interaction of goat manure types with weed management on weed control efficiency in 2020 (Table 2).

Interaction of goat manure rate and weed management strategies on weed density and weed control efficiency

The result of the interaction of goat manure rates and weed management strategies on weed density in 2020 rainy season as presented in Table 3 revealed that application of 5 t/ha in combination with weed free recorded the lowest weed density which was statistically similar with result obtained when applied from 10 t/ha in combination with weed free. Plots that were applied with 5 t/ha of goat manure in combination with weedy check recorded the highest weed density in 2020 (Table 3). Interaction of goat manure rates and weed management strategies on weed density in 2021 rainy season is presented in Table 4 and the result showed that plots applied with 5 t/ha in combination with weed free recorded the lowest weed density, but statistically similar with result obtained with application of 10 t/ha in combination with weed free. Weedy check plots with 0 t/ha recorded the highest weed density in this study (Table 4).

Table 3: Interaction of goat manure and weed management strategies on weed density in 2020 rainy season at Lapai, Niger State

	Weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	60.50e	42.00h	30.83i	12.83mn	96.00b
5 t/ha	50.50g	28.00j	21.00kl	10.50n	106.33a
10 t/ha	62.50e	20.17l	13.67mn	9.33n	82.00c
15 t/ha	54.67f	25.00jk	16.00m	13.00mn	72.00d
SE±		1.431			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT

Table 4: Interaction of goat manure and weed management strategies on weed density in 2021 rainy season at Lapai, Niger State

	weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	55.00e	47.67f	22.50i	10.50l	106.17a
5 t/ha	51.17f	33.50g	16.83j	9.83l	76.17b
10 t/ha	64.00d	22.33i	15.33jk	10.17l	72.00c
15 t/ha	64.83d	28.67h	13.83jkl	12.50kl	74.83bc
SE±		1.328			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT

The result of the interaction of goat manure rates and weed management strategies on weed control efficiency is shown on Table 5. The result indicates that application of 5 t/ha in combination with weed free recorded the highest weed control efficiency, though the result was at par with the result obtained at 0 t/ha in combination with weed free. All the rates of goat manure in combination with weedy check recorded lowest weed control efficiency compared to other

treatments. This result is similar to the work of Singh *et al.* (2017) who reported that highest weed control efficiency (85) was achieved with weed free treatment of weed control in potato crop. These results on interaction of goat manure rate and weed control strategies reveal the importance of effective weed control strategies.

Table 5: Interaction of goat manure and weed management strategies on weed control efficiency in 2020 rainy season at Lapai, Niger State

	Weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	33.03i	48.66efg	65.37cd	83.53ab	0.00k
5 t/ha	40.95ghi	58.35de	73.63bc	90.82a	0.00k
10 t/ha	15.59j	45.96fgh	60.18d	79.75b	0.00k
15 t/ha	18.06j	36.95hi	49.52efg	56.03def	0.00k
SE±		3.402			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT

Growth parameters of maize affected by goat manure

Growth parameters such as maize stand count, plant height, leaf area, leaf area index and days to 50% flowering were significantly ($p \leq 0.05$) affected by goat manure rates and weed management strategies (Table 6). Application of goat manure at the rate of 10 t ha⁻¹ recorded the higher number of stand count than the plots without treatments in both seasons, although the result was statistically similar with result obtained in plots applied with 10 t/ha in 2020. Significant ($p < 0.05$) taller plants were produced with increase in goat manure application up to 15 t ha⁻¹ while the shortest plant was obtained from plots without any amendment in both seasons. Significant taller plants were recorded under plots with weed free treatments which produced significantly taller plants than other treatments in both seasons. The weedy check plot consistently recorded the shortest plants. Highest number of leaves in 2020 was recorded from plots applied with 5 t ha⁻¹ but statistically at par with the application of 10 t ha⁻¹ while application of 0 t ha⁻¹ and 15 t ha⁻¹ recorded the least number of leaves. In 2021, application of 15 t ha⁻¹ recorded the highest number of leaves compared with all other treatment which recorded similar number of leaves. The increasing rate of goat manure from 10 and 15 t ha⁻¹ in both seasons resulted in corresponding significant wider leaf area, while the shortest leaf area was produced with application of 0 t ha⁻¹ in both years. In both years, significant ($p < 0.05$) highest leaf area index was obtained with the application of 10 and 15 t ha⁻¹ which in turn was higher than 5 t ha⁻¹ and the control. Days to 50% flowering in maize was significantly ($p < 0.05$) affected by goat manure rates. Similar shortest days to 50% flowering were observed with increasing rates of goat manure up to 15 t ha⁻¹. Plots with 0 t/ha recorded the longest days to 50% flowering (Table 6).

The systematic reduction in the manure rate significantly reduced plant height, number of leaves per plant, leaf area and the leaf area index. The apparent increase in these characters due to the progressive increase in manure rates reduced plant competition for growth resources. However, the application of 10 t ha⁻¹ goat manure that resulted in the largest plant stand count, leaf area and leaf area index, including taller plants at 15 t/ha⁻¹ could be as a result of greater critical nutrient levels in goat dung used as a soil amendment. This was consistent with the findings of Umoh *et al.* (2023), who discovered that manure obtained from provided balanced nutrients to plant roots and growth stimulation in grain yield of maize. Talip and Sison (2017) likewise found that when goat manure application rates increased, so did all maize growth indicators. However, there was general decrease in growth and development at lower goat manure rates, probably as a result of induced competition for growth resources. However, the control plot did not receive any goat manure and so had the lowest growth characteristics. This is similar to the report of Ibrahim and Hama (2012) who cited that the control treatments had the lowest mean value of all the growth parameters.

Growth parameters of maize affected by weed control strategies

Maize stand count was not affected by weed control methods in 2020, but significant ($p < 0.05$) difference was observed in 2021 such that weeding twice recorded the highest maize stand count, which was at par with all other weed management strategies except weeding once at 3 WAS. Weed free plots recorded the tallest plant, highest number of leaves, wider leaf area and leaf area index in both seasons. The result is closely followed by weeding thrice at 3, 6 and 9 WAS.

Table 6 . Effect of goat manure and weed management strategies on growth parameters of maize at 9 WAS in 2020 and 2021 rainy seasons at Lapai, Niger State

Treatments	Stand count		Plant height		Number of leaves		Leaf area		Leaf area index		Days to 50% flowering	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021		
Goat manure rates												
0 t/ha	42.27c	45.33c	67.60d	68.48d	11.17b	11.53b	268.0c	268.8c	58.88c	59.73c	69.33a	67.33a
5 t/ha	46.33b	46.73b	90.58c	91.43c	11.83a	11.83b	309.5b	310.3b	68.11b	68.96b	64.80b	62.80b
10 t/ha	47.40a	47.67a	101.02b	101.27b	11.53ab	11.83b	348.2a	349.0a	76.71a	77.56a	63.43b	61.43b
15 t/ha	47.00a	47.7ab	113.67a	114.52a	11.37b	12.30a	362.5a	363.4a	79.90a	80.75a	63.40b	61.40b
SE±	0280	0.259	2.01	2.84	0.154	0.126	7.72	7.72	1.716	1.716	0.5	0.516
Weed management strategies												
Weeding once at 3 WAS	46.00	42.21b	77.72d	78.57d	10.75c	11.17c	288.0d	288.9d	63.34d	64.19d	67.08b	65.08b
Weeding twice at 3 and 6 WAS	46.88	47.25a	98.17c	99.02c	11.58b	11.96b	326.6c	327.5c	71.92c	72.77c	64.00c	62.00c
Weeding thrice at 3, 6 and 9 WAS	46.62	46.88ab	108.30b	109.15b	11.83b	12.33b	367.2b	368.0b	80.93b	81.78b	62.42c	60.42c
Weed free	46.67	46.88ab	120.12a	120.97a	12.54a	12.92a	397.7a	398.6a	87.72a	88.57a	60.62d	58.62d
Weedy check	46.33	46.54ab	61.78e	62.63e	10.67c	11.00c	230.7e	231.5e	50.60e	51.45e	72.08a	70.08a
SE±	0.313	0.290	2.25	2.25	0.172	0.141	8.4	8.64	1.919	1.919	0.6	0.577
Interaction												
GM × WR	NS	NS	**	**	NS	NS	*	*	NS	NS	NS	NS

Means with the same letter (s) in a treatment column are not significantly different using Duncan Multiple Range Test (DMRT) at 5% level of probability. NS= not significant, *= significant at 5% level, **= highly significant at 1% level.

The shortest plant, least number of leaves, thinnest leaf area and lowest leaf area index were observed under weedy check, though in both years similar lowest number of leaves was recorded in plots administered with weeding once at 3 WAS. The significant higher number of leaves per plant was reflected in a significant increase in leaf area and leaf area index. This might have enhanced better growth and development of the crop. The plots treated with weed free recorded the shortest days to 50 % flowering while weeding twice and weeding thrice recorded similar number of days to flowering which was shorter than weeding once. Weedy check recorded the longest days to flowering (Table 6). Higher significant difference at $p < 0.01$ on interaction of goat manure and weed management.

Interaction of goat manure and weed management strategies on growth parameters

The interaction of goat manure and weeding regime on plant height of maize in 2020 and 2021 including leaf area at 9 WAS in 2020 and 2021 is presented in Tables 7 – 10 respectively. In both years, application of 15 t ha⁻¹ of goat manure in combination with weed free treatment produced the tallest plant which is statistically at par with plots applied with 10 t ha⁻¹ including weeding thrice in combination with 15 t/ha of the goat manure. The shortest plants were observed with 0 t/ha in combination with weeding once and weedy check which was similar to the result obtained at 5 t/ha with weedy check (Tables 7). Similar trends of result were observed in the interaction of goat manure and weed management strategies on plant height at 9 WAS in 2021 as shown in Table 8). Interaction of the two factors with leaf area in 2020 and 2021 follow similar trends in which 15 t ha⁻¹ in combination with weed free recorded the widest leaf area, but statistically at par with 15 t ha⁻¹ in combination with weeding thrice in both years, while 0 t ha⁻¹ in combination with weedy check recorded the shortest leaf area (Table 9 and 10). strategies was observed in both years on plant height and leaf area at $p < 0.05$ level of probability. Significant increases in growth parameters of maize may be due to goat manure. Application rate of gat manure at 15 t/ha of significantly increased the growth attributes of sweet maize, grain yield, and also hastened days to 50% tasseling as reported by Uwah *et al.* (2014).

Table 7: Interaction of goat manure and weed management strategies on plant height at 9 WAS in 2020 rainy season at Lapai, Niger State

	Weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	58.39h	68.08fgh	73.56fg	80.75ef	56.39h
5 t/ha	81.40ef	92.87de	97.87de	121.59c	59.06h
10 t/ha	79.12ef	105.32d	123.86c	133.09abc	3.74gh
15 t/ha	91.96de	125.64bc	137.81ab	145.04a	67.93fgh
SE±		4.49			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT.

Table 8: Interaction of goat manure and weed management strategies on plant height at 9 WAS in 2021 rainy season at Lapai, Niger State

	Weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	59.24h	69.73fgh	74.41fg	81.60ef	57.24h
5 t/ha	82.25ef	93.72de	98.82d	122.44c	59.31h
10 t/ha	79.97ef	106.17d	124.71c	133.94abc	64.89gh
15 t/ha	92.81de	126.48bc	138.66ab	14.89a	68.78fgh
SE±		4.49			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT.

Table 9: Interaction of goat manure and weed management strategies on leaf area at 9 WAS in 2021 rainy season at Lapai, Niger State

	Weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	227.4jk	283.4ghi	297.8fgh	320.3e-h	210.7k
5 t/ha	280.9hij	306.0e-h	350.4def	381.2cd	228.9jk
10 t/ha	33.6d-g	361.1de	385.7bcd	416.0bc	241.4ijk
15 t/ha	307.0e-h	355.9de	434.7ab	473.4a	241.7ijk
SE±		17.27			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT

Table 10: Interaction of goat manure and Weed management strategies on leaf area at 9 WAS in 2021 rainy season at Lapai, Niger State

	Weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	228.4jk	284.2ghi	298.7fgh	321.2e-h	211.6k
5 t/ha	281.7hij	306.8e-h	351.2def	382.1ed	229.8ijk
10 t/ha	337.4d-g	362.0de	386.5bcd	416.bcd	242.2ijk
15 t/ha	307.9e-h	356.8de	435.6ab	474.2a	242.6ijk
SE±		17.27			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT

Yield parameters of maize:

Yield parameters such as Dry cob weight, grain yield and combined analysis of each significantly ($p < 0.05$) showed variation in both seasons as affected by goat manure rates and weed management strategies (Table 11}. Result indicates that dry cob weight of maize with an application of 15 t/ha was superior to all the rates in both years including the combined. Likewise, highest grain yield of maize was received with application of 15 t ha⁻¹ including at combined. In this study, applying 15 t ha⁻¹ of goat dung consistently increased maize dry cob and grain yields. This could be due to the higher organic carbon and total nitrogen content in goat dung, which may have increased soil fertility and allowed for consistent larger grain harvests. This conclusion is consistent with the findings of Boateng *et al.* (2006), who found that grain yield increased with the rate of manure treatment. Organic matter generated from organic sources enhanced soil quality and fertility, decreased soil erosion, and increased agricultural output (Usman 2013). Yield components of maize such as cob length, cob diameter, number of seeds per cob, 1000 seed weight, and seed yield all improved in treatments with varying goat dung application rates as reported by Abdulkareem *et al.* (2024). It was also reported by Talip and Sison (2017) who conducted a study to compare the performance of Sweet Corn when applied with Goat Manure and Bio-N. They recommended maximizing goat manure fertilizer input up to 15 t ha⁻¹ in order to meet the nutritional requirements of the crops for normal growth and development, as well as optimizing yield capacity.

In the management strategies, plots that received weed free treatment significantly recorded the highest dry cob weight and grain yield in both seasons which was followed by weeding thrice while the least was recorded under weedy check plots in both years and combined. From this study it was therefore observed that a weed-free environment in the early stages allows crop seedlings to establish strong root systems and develop a robust canopy, giving them a competitive advantage over any later-emerging weeds to obtain good crop growth and yield. Colbach *et al.* (2023) reported a key role of competition for resources of which they cited that earlier emerging weeds are more harmful for the crop yield than late emerging weeds. In this regard therefore, weed free treatment can give better crop yield compared to other treatments in this study. Interaction of the goat manure and weed control strategies was observed on dry cob weight across seasons (Table 11)

Interaction of goat manure and weed management strategies on yield parameters of maize

Interaction of goat manure and weed management strategies on dry cob weight in both years are presented in Tables 12 and 13. Result indicates that in 2020, application of 15 t ha⁻¹ of goat manure in combination with weed free treatment recorded the highest dry cob weight which was higher ($p \leq 0.001$) than other treatments (Table 12). The lowest dry cob weight in 2020 was seen in plots in weeding once and weedy check in combination with 0 t/ha respectively. Similar trend of interaction of goat manure and weed management strategies was observed on dry cob weight in 2021 as shown in Table 13.

Table 11. Effect of goat manure and Weed management strategies on growth parameters of maize in 2021 rainy seasons at Lapai, Niger State

Treatments	Dry cob weight t ha ⁻¹		Combined	Grain Yield Kg ha ⁻¹		Combined
	2020	2021		2020	2021	
Goat manure rates						
0 t/ha	0.524d	0.609d	0.566d	0.397d	0.482d	0.440d
5 t/ha	0.971c	1.056c	1.013c	0.755c	0.840c	0.798c
10 t/ha	1.459b	1.544b	1.502b	0.993b	1.078b	1.035b
15 t/ha	1.853a	1.938a	1.895a	1.515a	1.006a	1.558a
SE±	0.041	0.041	0.028	0.046	0.046	0.031
Weeding regime						
Hw at 3 WAS	0.996c	1.081c	1.038d	0.776c	0.861c	0.819c
Hw at 3 and 6 WAS	1.165b	1.250b	1.207c	0.926b	1.011b	0.969b
Hw at 3, 6 and 9 WAS	1.276b	1.361b	1.319b	0.990b	1.075b	1.033b
Weed free	2.073a	2.158a	2.116a	1.504a	1.589a	1.546a
Weedy check	0.498d	0.583d	0.541e	0.379d	0.464d	0.421d
SE±	0.046	0.046	0.031	0.051	0.051	0.035
Interaction						
GM × WR	**	**	NS	NS	NS	SN

Means with the same letter (s) in a treatment column are not significantly different using Duncan Multiple Range Test (DMRT) at 5% level of probability. NS= not significant, *= significant at 5% level, **= highly significant at 1% level.

Table 12: Interaction of goat manure and Weed management strategies on dry cob weight in 2020 rainy season at Lapai, Niger State

	Weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	0.293j	0.526hij	0.582g-j	0.859g	0.359j
5 t/ha	0.748gh	0.859g	0.859fg	1.971c	0.415ij
10 t/ha	1.137f	1.415e	1.637de	2.582b	0.426hij
15 t/ha	1.804cd	1.859cd	2.026c	2.882a	0.693ghi
SE±		0.092			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT

Table 13: Interaction of goat manure and weed management strategies on dry cob weight in 2021 rainy season at Lapai, Niger State

	Weed management strategies				
	Weeding once	Weeding twice	Weeding thrice	Weed free	Weedy check
Goat manure rates					
0 t/ha	0.193j	0.415g-j	0.471f-j	0.659efg	0.248ij
5 t/ha	0.582e-h	0.671efg	0.748def	1.471b	0.304hij
10 t/ha	0.804cde	1.037cd	1.082c	1.637b	0.404g-j
15 t/ha	1.526b	1.582b	1.659b	2.248a	0.559e-i
SE±		0.102			

Means followed by the same letter(s) across the column are not significantly different at 5% level of probability using DMRT

CONCLUSION

The application of 15 t ha⁻¹ of goat dung was preferred because it supported the highest plant stand count, plants height and greater leaf area of maize, as well as yield and yield components. The weed-free treatment resulted in little or no weed-crop competition, perhaps creating a favorable environment for maize growth and yield. Finally, 15 t ha⁻¹ under weed-free circumstances is recommended to meet crops' nutritional needs for appropriate growth and development, resulting in maximum output. However, because weed control can be time-consuming, difficult, and costly, weeding thrice at 3, 6, and 9 WAS may be a reasonable alternative in the Southern Guinea Savanna, Nigeria.

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