Maize Response to Varying Weed Control Times: Growth, Yield, and Correlation Insights

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ABSTRACT

Maize (*Zea mays* L.), a major global grain crop, suffers yield losses of up to 80% from weed competition if not timely managed, especially in sub-Saharan Africa. Early-season weed control enhances canopy development and grain formation, yet its combined effect on growth and yield remains underexplored. This study examined maize response to varying weed control times in Nigeria's rainforest agro-ecological zone using a Randomized Complete Block Design with four treatments: weed-free (0 WAP), weeding at 2 WAP, 4 WAP, and 6 WAP, replicated four times. Growth traits (plant height, leaf area, stem girth, leaf length, number of leaves) and yield components (cob length, cob weight, grain yield, 100-seed weight) were assessed. Early weed control (0–4 WAP) significantly improved vegetative growth (2–12 WAP) and yield, with weed-free plots producing the highest cob length (15.42 cm), cob weight (32.80 g), and grain yield (23.16 t/ha). Correlation analysis revealed strong positive relationships within growth and yield parameters, with only a weak negative correlation (-0.47*) between number of leaves and cob length. Findings confirm a critical weed control period within the first 4 WAP, essential for optimizing maize growth and yield.

Keywords: Correlation, Growth, Yield, Weed control time

1.0 Introduction

One of the main staple cereals and a key component of global food security is maize (*Zea mays* L.). In addition to being a vital food staple for humans, it is also a vital source of feed for animals and a raw ingredient for a number of industrial goods, including bioethanol and starch derivatives (FAO, 2023). With average yields of about 5.7 tons per hectare, maize is grown on more than 200 million hectares worldwide. However, insufficient fertilizer use, dryness, pests, diseases, but most importantly weed competition causes yield loss in sub-Saharan Africa making it to frequently falling below 2 tons per hectare (Smith & Johnson, 2021).

Weeds are significant biotic challenge to maize farming because they minimize growth and yield potential by competing with maize plants for water, nutrients, light, and physical space. There is about 30% to 80% loss in maize yields due to weed infestation and ineffective management (Ogunlela et al., 2022). Farmers frequently weed irregularly, either because of labor shortages, unpredictable rainfall, or a lack of awareness, which results in suboptimal yield outcomes. Some of the main issues are that, although early weeding is generally known to be beneficial, the precise weed-free critical period within local contexts is still not well defined. Without proper timing, early weed control may not be sufficient, while late weeding may be ineffective. Without evidence-based timing guidelines, some people fail to weed at the proper development stage or waste effort on pointless weeding. In order for extension initiatives and policies to support effective, yield-maximizing practices, it is imperative to produce empirical data on the effects of weed control scheduling on maize development and production under rainforest agroecological zone.

Although, it is an established fact that timely weed control, particularly in the first several weeks after maize emergence is essential because growth, canopy and root dominance which are difficult to prevent later are established at the early stage, of which the presence of weed at this period will have severe disproportionate competitive damage on maize growth (Zhou et al., 2020). Hence, integrated approaches and that delayed weeding beyond a critical weed-free period (usually 3–4 weeks after crop emergence) leads to sharp decreases in biomass accumulation and grain yield (Gomez &

O'Smith, 2023; Karim et al., 2024). Despite these discoveries, the relevance of many earlier researchers to local farming settings was limited because they were carried out in other climates or production systems and none have confirmed the relationships between the growth and yield parameters under a varied weed control time. Therefore, this study aims to investigate not just the effects of timing weed control interventions on maize growth dynamics and final yield in rainforest agroecological zone by comparing early weeding but also aim at investigating the relationship between the growth and yield parameters of maize.

2.0 Materials and Methods

The field experiment was conducted at the Teaching and Research Farm of Federal Polytechnic Ilaro located in Yewa South Local Government Ogun State, Nigeria between month of April and August 2025. An enhanced open-pollinated SAMMAZ 15 maize variety, which is commonly grown in Nigeria, was utilized for the experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) having four treatments in each of the four blocks, which correspond to various weed control schedules; Weed-free for the entire time(0WAP/Control), weeding at two weeks after planting (2WAP), weeding at four weeks after planting (4WAP), and weeding at six weeks after planting (6WAP). Prior to planting, the land was prepared manually and the soil pulverized with the aid of local hoes, the seeds were planted on a raised bed, each drill hole got two seeds, which were thinned to a single, more vigorous stand two weeks after emergence (WAE). The planting space of 75 cm × 25 cm maize seeds resulting in 10 maize stands per plot (1m x 3m), 60 stands per block (10m x 25m) and 120 stands for the entire experimental field (45m x 110m). To reduce interference, there were 1 m alley between plots and 2 m between blocks. Fertilizer in the form of NPK 15:15:15 at the rate of 5g per stand at the 4week after planting and urea fertilizer of 5g per stand at 8 weeks after Planting.

In line with the experimental design, weed control measures were implemented and manually controlled with the aid of hoes at predetermined time intervals of 0, 2, 4, or 6WAP and were kept weed free till the end of the experiment after the allotted weed control time. Data on growth parameters were collected from three randomly chosen plants per plot were Plant height (cm) using a meter rule, measured every two weeks beginning at 2 WAP, from the soil surface to the tip of the highest leaf. Number of leaves by counting to determine the number of leaves on each plant. Leaf Length by using a measuring tape or ruler to measure from the leaf base to the leaf tip, Leaf width by using a tape measure or a ruler to measure across the leaf's broadest area, stem grith by Encircling venire caliper round the base part of the stem and Leaf Area was determined mathematically by the equation (i)

$$Leaf\ Area\ (LA) = Length\ X\ Width\ X\ 0.75$$

The data on yield parameters were collected at harvest (15WAP) from plants chosen at random, these include the number of cobs per plant by counted from plants. Cob diameter and length were measured with a ruler and vernier caliper. Grain weight per cob (g) was determined after shelling and drying to 12–14% moisture content. One hundred seed weight was determined using a weighing balance to weigh 100 seeds after counting and Grain yield was determined mathematically by equation (ii).

$$Grain\ Yield\ (kg/ha) = Yield\ per\ m^2\ X\ 10{,}000 \ldots\ldots\ldots\ldots (ii)$$

Data was analyzed with the aid of statistical Package for Social Sciences (SPSS version 21), by carrying out analysis of Variance (ANOVA) on the collected data and means were separated using Duncan multiple Range Test (DMRT) at a 5% probability level ($p \leq 0.05$). Additionally, correlation studies were performed to investigate the connections between maize growth and yield parameters.

3.0 Results and Discussion

Table 1 shows Leaf width differed significantly among treatments during the early growth stages indicating that the weed-free treatment consistently produced the widest leaves at 2 and 4 WAP (6.08 cm and 6.55 cm, respectively), which were statistically superior to delayed weeding treatments such as weed-free at 4 WAP (3.90 cm) and weed-free at 6 WAP (2.18 cm). This demonstrates that early weed competition significantly suppressed leaf expansion. Although some compensatory growth occurred in later weeks, particularly in the weed-free at 6 WAP treatment (7.90 cm at 14 WAP), plants never fully matched the continuous weed-free plots.

Table 1 on number of leaves per plant was also influenced by weed control time, weed-free at zero-week plots consistently produced more leaves during early and mid-growth stages, while weed-free at 6 WAP recorded the lowest counts early on (5.33 at 2 WAP). Later in the season, differences narrowed, suggesting partial recovery.

Table 2 Mean Performance of Number of leaves

TREATMENT	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Weed Free at 0WAP	6.83[a]	4.67[a]	8.83[a]	10.00[a]	9.83[a]	9.83[a]	9.00[a]
Weed Free at 2WAP	6.33[ab]	8.33[a]	8.50[a]	8.67[ab]	9.00[a]	9.33[a]	9.50[a]
Weed Free at 4WAP	6.83[a]	7.67[a]	8.83[a]	9.17[ab]	9.67[a]	9.50[a]	8.83[a]
Weed Free at 6WAP	5.33[b]	5.17[b]	6.17[b]	8.00[b]	9.83[a]	9.83[a]	9.00[a]
LSD	0.09	0.01	0.00	0.04	0.36	0.74	0.41

Key: WAP- Week After Planting; LSD- Least Significant Difference. Means with the same letter along the columns are not significantly different using DMRT (P< 0.05)

Table 3 shows that Stem girth has less consistent treatment weed-free at 4 and 6 WAP recorded significantly lower girth (2.63 cm and 3.68 cm respectively) compared to weed-free plots (4.11 cm). However, many treatments were statistically similar at later stages.

Table 3 Mean Performance of Stem Girth

TREATMENT	2WAP (cm)	4WAP (cm)	6WAP (cm)	8WAP (cm)	10WAP (cm)	12WAP (cm)	14WAP (cm)
Weed Free at 0WAP	5.25[a]	5.93[a]	6.12[a]	7.28[a]	5.98[a]	5.32[a]	4.88[a]
Weed Free at 2WAP	3.75[a]	6.25[a]	6.02[a]	6.92[a]	4.88[ab]	4.75[a]	4.78[a]
Weed Free at 4WAP	4.58[a]	5.97[a]	6.32[a]	5.93[a]	4.63[b]	4.52[a]	4.70[a]
Weed Free at 6WAP	4.95[a]	2.63[b]	3.68[b]	5.93[a]	4.89[b]	5.38[a]	4.62[a]
LSD	0.89	0.00	0.01	0.15	0.08	0.16	0.97

Key: WAP- Week After Planting; LSD- Least Significant Difference. Means with the same letter along the columns are not significantly different using DMRT (P< 0.05)

Table 1 Mean Performance of Leaf width

TREATMENT	2WAP (cm)	4WAP (cm)	6WAP (cm)	8WAP (cm)	10WAP (cm)	12WAP (cm)	14WAP (cm)
Weed Free at 0WAP	6.08[a]	6.55[a]	7.80[ab]	9.47[a]	7.00[a]	7.25[a]	7.45[a]
Weed Free at 2WAP	5.22[ab]	6.22[a]	8.45[a]	8.67[ab]	6.50[ab]	6.55[a]	5.50[b]
Weed Free at 4WAP	3.90[b]	6.37[a]	5.62[bc]	7.13[c]	5.13[b]	5.87[a]	6.65[ab]
Weed Free at 6WAP	2.18[c]	3.42[b]	4.78[c]	6.55[c]	5.67[b]	6.77[a]	7.90[a]
LSD	0.00	0.00	0.00	0.01	0.11	0.49	0.04

Key: WAP- Week After Planting; LSD- Least Significant Difference. Means with the same letter along the columns are not significantly different using DMRT (P< 0.05)

Table 4 shows leaf length followed a similar pattern to leaf width. Weed-free plots produced significantly longer leaves early (55.58 cm at 2 WAP) compared to weed-free at 6 WAP (23.42 cm). By 14 WAP, delayed weeding treatments exhibited partial catch-up (70.62 cm), but early canopy advantage of weed-free plots was evident.

Table 4 Mean Performance of Leaf Length

TREATMENT	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Weed Free at 0WAP	55.58[a]	63.43[a]	67.22[a]	68.90[a]	62.58[a]	63.37[a]	63.52[ab]
Weed Free at 2WAP	46.17[b]	65.37[a]	67.72[a]	68.80[a]	65.52[a]	69.82[a]	68.33[ab]
Weed Free at 4WAP	62.17[a]	58.77[a]	66.47[a]	67.58[a]	67.58[a]	58.87[a]	55.97[b]
Weed Free at 6WAP	23.42[c]	30.47[b]	39.88[b]	50.43[b]	63.83[a]	68.02[a]	70.62[b]
LSD	0.00	0.00	0.00	0.13	0.85	0.23	0.13

Key: WAP- Week After Planting; LSD- Least Significant Difference. Means with the same letter along the columns are not significantly different using DMRT (P< 0.05)

Table 5 shows Plant height was severely affected by weed competition, weed-free at 6 WAP plants were markedly shorter (17.18 cm) than weed-free plots (50.08 cm). Although some recovery occurred, weed-free plants consistently maintained height superiority throughout the growth cycle.

Table 5 Mean Performance of Plant Height

TREATMENT	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Weed Free at 0WAP	50.08[a]	69.67[ab]	88.93[a]	119.02[ab]	130.17[a]	136.48[a]	135.57[a]
Weed Free at 2WAP	43.00[b]	78.25[a]	88.93[a]	97.23[b]	114.77[a]	128.07[a]	131.28[a]
Weed Free at 4WAP	59.75[a]	59.82[a]	101.83[a]	121.50[a]	130.48[a]	131.12[a]	129.73[a]
Weed Free at 6WAP	17.18[c]	24.50[a]	32.23[b]	48.08[c]	68.57[b]	104.78[b]	116.72[a]
LSD	0.00	0.00	0.00	0.00	0.00	0.02	0.27

Key: WAP- Week After Planting; LSD- Least Significant Difference. Means with the same letter along the columns are not significantly different using DMRT (P< 0.05)

Table 6 shows Leaf area was significantly larger in weed-free plots (498.55 cm² at 8 WAP) compared to delayed weeding treatments. Weed-free at 6 WAP plants recorded drastically reduced early leaf area (73.35 cm² at 2 WAP), demonstrating the suppressive effects of early weed competition.

Table 6 Mean Performance of Leaf Area

TREATMENT	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Weed Free at 0WAP	272.82[a]	262.00[b]	464.37[a]	498.63[a]	343.05[a]	315.18[a]	357.90[ab]
Weed Free at 2WAP	250.18[ab]	353.40[a]	353.68[a]	406.87[a]	321.95[a]	367.40[a]	355.67[ab]
Weed Free at 4WAP	253.33[ab]	271.18[ab]	418.95[a]	458.39[a]	292.18[a]	273.55[a]	247.38[b]
Weed Free at 6WAP	73.35[b]	78.63[b]	145.82[b]	248.47[b]	278.20[a]	352.67[a]	418.95[a]
LSD	0.09	0.00	0.01	0.01	0.69	0.46	0.15

Key: WAP- Week After Planting; LSD- Least Significant Difference. Means with the same letter along the columns are not significantly different using DMRT (P< 0.05)

Table 7 shows Weed-free plots significantly outperformed other treatments for all yield parameters. Weed-free plants recorded the highest cob length (15.42 cm), cob weight (32.80 g), grain yield (23.16), and 100-seed weight (7.60 g). Conversely, delayed weed control reduced these yield attributes, with weed-free at 2 WAP and 6 WAP producing lower grain yield (19.36 and 20.06, respectively).

Table 7 Mean Performance of Yield Parameter

TREATMENT	Cob Length (cm)	Cob Weight (g)	100 seeds (g)	Grain Yield (Kg/ha)
Weed Free at 0WAP	15.42[a]	32.80[a]	7.60[a]	23.16[a]
Weed Free at 2WAP	12.72[b]	28.50[b]	6.22[b]	19.36[b]
Weed Free at 4WAP	14.40[ab]	28.00[b]	7.42[a]	20.82[ab]

Weed Free at 6WAP	13.66[ab]	27.20[b]	6.80[a]	20.48[ab]
LSD	0.050	0.03	0.46	0.15

Key: WAP- Week After Planting; LSD- Least Significant Difference. Means with the same letter along the columns are not significantly different using DMRT (P< 0.05)

Table 8 shows Correlation analysis (Table 4.8) highlighted cob length and cob weight as the strongest predictors of grain yield (r = 0.95** and r = 0.92**, respectively). This indicates that grain yield in maize is primarily determined by cob size

Table 8 Correlation of the Growth and Yield Parameters

	Plant Height	Leaf Area	Num. of Leaves	Leaf Length	Steam Girth	Leaf Width	Cob Length	Cob weight	Grain Yield	100Seeds (g)
Plant Height	1	0.27	0.63**	0.03	0.48*	-0.03	-0.30	-0.17	-0.28	-0.16
Leaf Area		1	0.48*	0.78**	0.28	0.28	-0.05	0.08	0.11	0.27
Num of Leaves			1	0.27	0.64**	0.19	-0.47*	-0.29	-0.40	0.04
Leaf Length				1	0.14	0.15	-0.09	-0.04	0.03	0.23
Stem Girth					1	0.22	-0.42	-0.34	-0.44	-0.14
Leaf Width						1	-0.13	-0.20	-0.06	-0.06
Cob Length							1	0.90**	0.95**	0.61**
Cob weight								1	0.92**	0.61**
Grain Yield									1	0.64**
100Seeds (g)										1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Growth Parameter

The Leaf width significant difference among treatments at the early growth stages is a reflection that early weed competition significantly suppressed leaf expansion. Towards the end of the growing stage, it was indicated that delayed weeding induced late compensation that broke the early growth stage predictive trend. This pattern aligns with previous reports that early-season weed competition critically reduces light and nutrient availability, thus constraining canopy development (Horvath, 2023; Nedeljković et al., 2025).

The number of leaves per plant was also influenced by weed management as weed-free plots consistently produced more leaves during early and mid-growth stages. Although early vigor predicts mid-season leaf production, late compensation disrupts this progression. These findings corroborate the critical period for weed control (CPWC) concept, where early weed interference directly affects canopy development and potential photosynthesis (Landau et al., 2021; Iowa State Extension, 2022).

Stem girth showed less consistent treatment effects compared to leaf traits; many treatments were statistically similar at later stages. It is less directly influenced by weed competition than leaf area and height. Previous studies have shown that stem girth is more strongly linked to lodging resistance than to yield potential (Zhao et al., 2023).

Leaf length followed a similar pattern to leaf width as weed-free plots produced significantly longer leaves at the early and mid-season of growth but again reflecting compensatory growth at the end of the growing session. This confirms that early canopy suppression by weeds limits photosynthetic potential, consistent with earlier reports (Bavec, 2002; Nedeljković et al., 2025).

Plant height was severely affected by weed competition although some recovery occurred, weed-free plants consistently maintained height superiority throughout the growth cycle. It implies that plant height is an important indicator of vigor and competitive ability in maize, with early weed-free conditions ensuring maximum light interception and growth (Yang et al., 2024).

Leaf Area compared to delayed weeding treatments demonstrate the suppressive effects of early weed competition but later reflect compensatory growth at the late session of growth. Since leaf area directly determines light interception and radiation use efficiency, early weed suppression inevitably reduced cumulative biomass production (Zhao et al., 2023).

Yield Parameter

Weed-free plots significantly outperformed other treatments for all yield parameters as delayed weed control reduced these yield attributes, with weed-free at 2 WAP and 6 WAP producing lower grain yield. These findings emphasize the importance of maintaining weed-free conditions during the critical period of maize development. Early weed competition restricts resource availability during ear formation, leading to smaller cob size and reduced grain fill (Nedeljković et al., 2025; Landau et al., 2021).

Relationship Between the growth and yield parameter

Correlation analysis highlighted cob length and cob weight as the strongest predictors of grain yield. This indicates that grain yield in maize is primarily determined by cob size.

Vegetative vigour traits (height, leaf area) were positively correlated with each other, confirming that canopy development is interdependent. Similar patterns have been documented in maize studies where reproductive traits are stronger yield determinants than vegetative traits (Horvath, 2023; Yang et al., 2024).

4.0 Conclusion

This study investigated the impact of varying weed control time on the growth, yield and correlation of both parameters. It is therefore discovered that **early weed control (0–4 WAP)** is crucial for sustaining maize growth and maximizing yield. Delayed weed removal was noticed to suppressed early vegetative traits, but a compensatory growth at the late growing session was observed with delayed weed removal (6 WAP). However, yield losses remained evident in maize whose weed removal was delayed despite the compensatory vegetive growth at the end of the session. It was also revealed from this research that high vegetative growth especially at the late session of maize production may not culminate in high yield only early and sustained vegetative growth of maize will bring about high yield of maize.

RECOMMENDATION

It is hereby recommended that Weed management should prioritize early-season control (first 2–4 WAP). Cob traits (length, weight) can serve as reliable predictors of yield in breeding and field assessments. And early vegetative vigour measurements (height, leaf area) are strong indicators of future yield performance and can guide early interventions.

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