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# GROWTH ATTRIBUTES OF EXTRA-EARLY MAIZE (*Zea mays* L.) VARIETIES AS INFLUENCED BY PRE-AND POST-EMERGENCE HERBICIDES IN NORTHERN GUINEA SAVANNA OF NIGERIA

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## ABSTRACT

Two field trials were conducted during 2016 and 2017 wet seasons at Kaduna State Agricultural Development Project (KADP) Maigana Research Farm, to assess the performance of three extra-early maize varieties (SAMMAZ-29, 32 and 33). Treatments were laid out in a split plot design consisting of 12 weed control treatment combinations nicosulfuron (0.075 and 0.15kg a.i./ha), Atrazine + pendimethalin (2.0 +2.0 kg a.i./ha) each of these was applied alone, followed by hoe weeding at 5WAS and followed by nicosulfuron (0.075kg a.i./ha) at 5 WAS. The parameters measured include leaf area index (LAI), crop vigor score, relative growth rate and grain yield $ha^{-1}$. The result showed that SAMMAZ-29 and SAMMAZ-32 had the highest LAI at 12 WAS in 2016, and hoe weeding (weeded at 3 and 6 WAS) at all the sampling periods in 2016, and at 4WAS and 12WAS in 2017, which was statistically similar to Atrazine (2.0 kg a.i./ha) followed by nicosulfuron (0.075 kg a.i./ha) at 5 WAS produced the highest LAI in 2017; SAMMAZ-29 produced the highest crop vigor score (CVS) at 4 and 12 WAS in 2016, similarly in 2017 SAMMAZ-29 and SAMMAZ-33 had the highest CVS at 8 WAS and nicosulfuron (0.15 kg a.i./ha) at 2 WAS followed by nicosulfuron (0.075 kg a.i./ha) at 5 WAS and hoe weeding at 3 and 6 WAS significantly produced the highest CVS at 12 WAS in 2016. Similarly, in 2017, nicosulfuron (0.15kg a.i./ha) at 2 WAS followed by nicosulfuron (0.075 kg a.i./ha) at 5 WAS, produced the highest CVS at all the sampling periods. SAMMAZ-29 with nicosulfuron (0.15 kg a.i./ha) at 2 WAS followed by nicosulfuron (0.075 kg a.i./ha) at 5 WAS produced the highest Relative growth rate (RGR) at all the sampling periods in both seasons. SAMMAZ-29 with nicosulfuron (0.15 kg a.i./ha) at 2 WAS followed by nicosulfuron (0.075 kg a.i./ha) at 5 WAS produced the highest grain yield/ha in 2016 and the mean. It could be suggested that SAMMAZ-29/SAMMAZ-32 with the application of Nicosulfuron (0.15 kg a.i./ha) at 2 WAS followed by Nicosulfuron (0.075 kg a.i./ha) at 5 WAS could be used by farmers for weed management during the production of maize in the northern Guinea savannah ecological zone of Nigeria.

**Keywords:** Growth attributes; Extra-early maize; Herbicides

## INTRODUCTION

Maize (*Zea mays* L.), also called corn, is believed to have originated in central Mexico 7000 years ago from a wild grass, and Native Americans transformed maize into a better source of food. Maize contains approximately 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 Kcal/100 g and is grown throughout the world, with the United States, China and Brazil being the top three maize-producing countries in the world, producing approximately 563 of the 717 million metric tons/year. Maize is the most widely adapted and the most important cereal crop in the world in 2019 with current production of 1125.01 million metric tons followed by rice and wheat with 782.3 and 680.2 million metric tons respectively. United States of America is the largest producer, accounting for 32.56% of the world's total, followed by China and Brazil that accounted for 22.87% and 8.98% respectively (USDA, 2019). Africa produced 5.15% of the world's total from 191.91 million hectares. Nigeria is the second largest producer of Maize in Africa after South Africa with 11,000 million metric tons, which represented 0.97% of the world's total in 2018 (USDA, 2019). There was an increase in cultivated land area and production output for maize in many States in Nigeria in 2019. Kaduna State had the highest increase in cultivated land and production for maize in 2019 with the total production of 1000 metric tons with 400 land area (Hectares), followed by Niger State with 800 metric tons with cultivated land area of 250 hectares and Bayelsa is the State with least, 100 metric tons and land area of 50 hectares (NAERLS, 2019; FMARD, 2019). Maize can be processed into a variety of food and industrial products, including starch, sweeteners, oil, beverages, glue, industrial alcohol and fuel ethanol. Low production costs, along with the high consumption of maize flour and cornmeal, especially where micronutrient deficiencies are common public health problems, make this food staple an ideal food vehicle for fortification (Anon., 2014).

Maize requires annual rainfall of 600–1000 mm; sandy loam and silt loam soils containing adequate organic matter and tolerates soil pH from 5.5 to 8.0 but the optimum range is 5.5 – 7.0. For good growth, maize requires a lot of sunshine and warmth condition. Ideal temperature for its ranges between 21-27°C. The general fertilizer and spacing requirements of maize is NPK 120-60-60 kg N/ha, and 25 cm by 75 cm respectively, in the Northern Guinea Savanna of Nigeria (Wolkoski, 2001). The fresh immature grain is roasted or cooked and eaten directly (Delorit *et al.*, 1974). The dried grain is used for the preparation of porridge after milling and boiling. It is also used for the production of livestock feeds and in industries for the production of cornflakes, maize flour, sugar, oil, alcohol and non-alcoholic beverages, corn starch and production of bio-fuel. It can also be eaten as a whole grain when roasted or boiled (Fajemisin, 1991).

Manual hoe-weeding is the most predominant method of weed control in crop production among peasant farmers in Nigeria, however, it is tedious, slow and ineffective and drudgery under farm, sometimes the labor may not be readily available at the time of need and therefore costly (Lagoke, 1991). Consequently, the average yield (1.9 tons/ha) of maize in Nigeria is generally very low as compared to the potential yield of maize varieties of 3.0 to 6.5 t/ha, (Anon., 2014). Weeding takes between 21-32% of the total time devoted to maize production in Nigeria. To address these draw-backs in manual weed management, different herbicides have been recommended for maize and maize based crop mixtures. However, biotic and abiotic factors within the eco-system have hindered the attainment of season-long weed control, resulting in the need for supplementary weed management (Akobundu *et al.*, 1994).

Hoe-weeding has been used to control weeds as supplement to the pre-emergence herbicides; however, such effort has proved equally controls, tedious and ineffective. In order to attain effective supplementary weed management, farmers have resorted to the use of directed spray of paraquat; this in turn has resulted in herbicide drift with serious scorching of maize leaves that may affect yields. It is in the light of these inadequacies of supplementary weed management through manual weeding or post-emergence paraquat application, that the use of nicosulfuron, a post-mergence systemic herbicide selective to maize, is being considered both as a primary treatment and as a supplement to itself and to a pre-emergence herbicide treatment. With new maize varieties, bred to address biotic and abiotic constraints such as parasitic weeds, low soil nitrogen and drought, there is the need to watch out for any differential responses of the varieties to these herbicides (Olsen and Sanders, 1988).

## MATERIALS AND METHOD

### The Study Area

Two field trials were conducted during the 2016 and 2017 wet seasons at the experimental site of Kaduna Agricultural Development Project (KADP) located at Maigana, Soba Local Government Area ($11^0$39'N; $08^0$ 02' E, 500 m above the sea level) in the Northern Guinea Savanna of Nigeria.

### Soil Analysis

Five soil samples were taken randomly from the depth of 0-30cm across experimental fields prior to land preparation; a composites soil sample was taken to the laboratory for analyses to ascertain the physical and chemical properties of the soil using standard analytical procedures (IITA, 1975).

### Treatments and Experimental Design

The treatments consisted of 12 weed control treatments; Nicosulfuron (0.075 kg a.i./ha and 0.15 kg a.i./ha), each was applied alone at 2 WAS, followed by hoe weeding at 5 WAS and followed by Nicosulfuron (0.075 kg a.i./ha) at 5 WAS, atrazine plus Pendimethalin (2.0 + 2.0 kg a.i./ha) alone as pre-emergence and followed by hoe weeding at 5 WAS, and followed by Nicosulfuron (0.075 kg a.i./ha) at 5 WAS, atrazine alone (2.0 kg a.i./ha) followed by Nicosulfuron (0.075 kg a.i./ha) at 5 WAS, a hoe-weeded control (weeded at 3 and 6 WAS) and a weedy check using three extra-early maturing maize varieties (SAMMAZ-29, SAMMAZ-32 and SAMMAZ-33). The treatments were laid out in a split plot design, the weed control treatments in the main plot, while varieties were in the subplot, and replicated three times. The gross plots consisted of 6 ridges each 0.75 m wide and 4.0 m long (18 $m^2$), while net plot size consisted of 4 inner ridges each 4.0 m long and 3.0 m wide (12 $m^2$).

### Varietal Description

SAMMAZ-29 (2000 TZEE-W-STR): It is extra-early maturing and takes 57 days to mid-silking and 80-85 days to physiological maturity under striga free conditions. The height is 170cm. It is white-seeded and has a potential yield of 4.0 t/ha. It is tolerant to *Striga hermonthica*, maize streak virus and drought tolerant (IAR, 2009).

SAMMAZ-32 (99TZEE-Y-STR): It is extra-early maturing variety (50 days to mid-silking and 80-85 days to physiological maturity). It has a height of 170cm, yellow-seeded kernels and a potential yield of 4.0 t/ha. It's tolerant to *Striga hermonthica* and Maize Streak Virus.

SAMMAZ-33 (95TZEE-Y-STR): It is extra-early maturing and takes 57 days to mid-silking and 80-85 days to physiological maturity under striga free conditions. The height is 155cm. It is yellow-seeded and has a potential yield of 4.0 t/ha. It is susceptible to *Striga hermonthica*, but tolerant to maize streak virus and drought tolerant (IAR, 2009).

**Cultural Practices**

The field was harrowed to a fine tilth, ridged 75 cm apart and then marked into plots and replications the gross and net plot size were 18m$^2$ and 12m$^2$ respectively. A space of 0.5m between the plots and 1m between replicates were used. The seeds were sown manually 2 seeds per hole at spacing of 25 x 75 cm and later thinned down to one plant per stand at two weeks after sowing. Fertilizer was applied at the rate of 120:60:60 kg/ha of NPK as side placement in two equal split doses. The first half dose of N and all P and K was applied at ten days after sowing using NPK 15:15:15, while the second dose of N using urea (46%N) was applied at 6WAS to meet the nutrients requirement of the crop.

**Pests and Disease Control**

There was severe incidence of stem borer infestation in 2016 wet season in both locations and was treated with insecticides Cypermethrin and Dimethoate at the rate of 0.75 kg a.i./ha by spraying, using a knapsack sprayer.

**Herbicides Application**

Atrazine, Pendimethalin and Nicosulfuron were applied as per treatment basis, using CP3 knapsack sprayer fitted with a green deflector polyjet nozzle and set at a pressure of 2.1 kg-m$^2$ to give a spray volume of about 250 L/ha. The spraying was done in the morning when the weather was calm to avoid drift.

**Harvesting**

Harvesting was done manually by removing the cobs when the crop reached physiological maturity, this was indicated by the formation of a black layer at the placental region (i.e. the point of attachments of grains on the cob).

**Data Collection**

***Leaf Area Index (LAI)*****:** This was measured at 4, 8 and 12 WAS. The length and the breadth from the widest point of a functional leaf were measured with a meter rule. The product of the length and the breadth was multiplied by a factor (0.75), to calculate the leaf area (Watson, 1958). To find the LAI, the leaf area obtained from the individual leaves was added and the average per plant computed and divided by the land area covered by the plant (Duncan and Hasket, 1968) as follows:

$$L = \frac{A}{P}$$

Where:
L = Leaf Area Index
A = Assimilatory surface
P = Ground area/plant

***Crop Vigor Score*****:** Crop vigor score was assessed visually at 4, 8 and 12 WAS, using a scale of 1 to 9, where 1 was given to a plot with completely dead plants, while scale 9 was given to the most vigorous plant, the assessing features of the plants used for scoring were; height, canopy spread and greenness of leaves.

***Relative Growth Rate (RGR)*****:** This was calculated at 4, 8, and 12 WAS. It was determined after oven drying of the plants to a constant weight using the formula by Fischer (1921).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} \, g/g/wk$$

Where $W_1$ and $W_2$ refers to whole plant dry weight at two successive times $t_1$ and $t_2$; $\text{Log}_e$ refers to natural logarithm of a number.

***Grain Yield*****:** The harvested cobs from each net plot were threshed, winnowed, and weighed; the grains were weighed and expressed in kilogram per hectare by extrapolation.

**Data Analysis**

General linear model procedure (GLM) of the statistical analysis system (SAS) package (SAS,1990) was used for statistical analysis of all the data collected and differences between the treatment means were compared using Duncan Multiple Range Test as described by Duncan (1955). Simple Correlation and Path Coefficient Analysis among the parameters were worked out using the procedure described by Dewey and Lu (1959) and Little and Hills (1978) to assess the type and magnitude of relationships among the variables.

## RESULTS

The varietal differences and the effect of weed control treatments on leaf area index of the three maize varieties at Maigana during 2016 and 2017 wet seasons are presented in Table 1. Varietal differences caused significant ($P<0.05$) differences at Maigana wet seasons. SAMMAZ–33 produced the highest LAI in the location, while Sammaz-29 had the least leaf area index. However, SAMMAZ–29 produced the highest LAI at Maigana during 2016 heat season, SAMMAZ–33 had the least LAI. The variation in weed control treatments caused significant difference in LAI. In Maigana there were significant differences in LAI at all the sampling period, in both seasons. There were significant differences among the treatments at all the sampling periods in 2016 and 2017. Hoe weeding produced significantly (P<0.05) the highest LAI than all the other weed control treatments, while W2 produced he least LAI. However, weedy check produced the highest LAI at 8 WAS in 2016 but was statistically similar to all other weed control treatments except at W2 and W6 which produced the least LAI, at 12 WAS in 2016 weedy check produced weed the highest LAI, while W8 recorded the least LAI in 2017. At 4 WAS W10 and W11 produced the highest LAI than the rest of the weed control treatments, while W2 and W4 produced the least, but were statistically similar to that recorded by W2, W5 and W9 weed control treatments. Similar trends were also observed at 8 WAS, where W10 produced the highest LAI among the weed control treatments, but was statistically similar to W1, W4, W8, W11 and W12. Similarly, at 12 WAS, W11 produced the highest LAI, while W3 and W4 produced the least.

Table 1: Leaf Area Index of extra-early maize varieties as influenced by weed control treatments at Maigana, 2016 and 2017 wet seasons in the northern guinea Savanna of Nigeria

| | 2016 | | | 2017 | | |
|---|---|---|---|---|---|---|
| Treatment | 4WAS | 8WAS | 12WAS | 4WAS | 8WAS | 12WAS |
| Variety (V) | | | | | | |
| SAMMAZ -29 | 0.28 | 1.97 | 1.20a | 0.73b | 2.27 | 1.97 |
| SAMMAZ -32 | 0.28 | 2.18 | 0.99a | 0.67b | 2.12 | 1.73 |
| SAMMAZ -33 | 0.26 | 2.13 | 0.93b | 1.02a | 2.21 | 1.73 |
| SE± | 0.023 | 0.108 | 0.062 | 0.042 | 0.135 | 0.125 |
| Weed Control (W) | | | | | | |
| W1 | 0.20cd | 2.06ab | 0.88bc | 0.75b-d | 2.75ab | 1.69ab |
| W2 | 0.15d | 1.82b | 1.28b | 0.46e | 1.60c | 1.63ab |
| W3 | 0.24cd | 2.05ab | 0.89bc | 0.57ed | 1.87c | 1.54b |
| W4 | 0.19cd | 2.02ab | 0.91bc | 0.43e | 2.28a-c | 1.50b |
| W5 | 0.23cd | 2.19ab | 0.89bc | 0.61ed | 1.72c | 2.11ab |
| W6 | 0.17cd | 1.66ab | 1.02bc | 0.83b-d | 2.79bc | 1.79ab |
| W7 | 0.24cd | 1.93ab | 0.97bc | 0.84b-d | 2.79bc | 1.94ab |
| W8 | 0.19cd | 2.21ab | 0.81c | 0.94cd | 2.46a-c | 2.12ab |
| W9 | 0.31c | 1.98ab | 0.88bc | 0.69c-e | 1.71c | 1.73ab |
| W10 | 0.49b | 2.35ab | 1.11bc | 1.24a | 2.91a | 1.77ab |
| W11 | 0.66a | 2.63a | 1.64a | 1.34a | 2.28a-c | 2.44a |
| W12 (Weedy Check) | 0.18cd | 2.13ab | 1.16bc | 6.98b | 2.12a-c | 2.13ab |
| SE± | 0.045 | 0.216 | 0.124 | 0.085 | 0.270 | 0.250 |
| Interaction | | | | | | |
| V x W | NS | NS | NS | NS | NS | NS |

Means followed by the same letter(s) within the same column and treatment group are not statistically different (P>0.05) using Duncan Multiple Range Test (DMRT)

Key:
W1= Nicosulfuron 0.075 a.i./ha at 2 WAS only
W2= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W3= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W4= Nicosulfuron 0.15 a.i./ha at 2 WAS only
W5= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W6= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W7= Atrazine + Pendimethalin 2.0+2.0 a.i./ha at 2 WAS only
W8= Atrazine + Pendimethalin. 2.0+2.0 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W9= Atrazine + Pendimethalin 2.0+2.0 fb 0.075 at 2 WAS followed by Nicosulfuron at 5 WAS
W10= Atrazine 2.0 fb 0.075at 2 WAS followed by Nicosulfuron at 5 WAS
W11= Hoe weeding at 3 and 6 WAS
W12= Weedy check

Table 2 shows varietal difference, effect of weed control treatments on crop vigor score (CVS) of maize at Maigana, 2016 and 2017 wet season. At Maigana in 2016, SAMMAZ-29 and SAMMAZ-32 produced the highest crop vigor score at all the sampling periods except at 12 WAS in which SAMMAZ-32 was not significantly different from SAMMAZ-33. However, SAMMAZ-33 produced the least crop vigor score.

Table 2: Crop vigor score of extra-early maize varieties as influenced by weed control treatments at Maigana, 2016 and 2017 wet Seasons in the northern guinea Savanna of Nigeria

| | 2016 | | | 2017 | | |
|---|---|---|---|---|---|---|
| Treatment | 4WAS | 8WAS | 12WAS | 4WAS | 8WAS | 12WAS |
| Variety (V) | | | | | | |
| SAMMAZ -29 | 7.94a | 8.41a | 8.11a | 8.27a | 8.41a | 8.80a |
| SAMMAZ -32 | 7.69ab | 8.19a | 7.88b | 8.19ab | 7.75b | 8.22c |
| SAMMAZ -33 | 7.58b | 6.72b | 7.72b | 8.00b | 7.55c | 8.38b |
| SE± | 0.108 | 0.172 | 0.071 | 0.086 | 0.066 | 0.053 |
| Weed Control (W) | | | | | | |
| W1 | 7.83 | 7.33 | 7.77c | 7.54d | 8.12c | 8.22de |
| W2 | 7.88 | 7.22 | 7.77c | 7.88cd | 8.11c | 8.22de |
| W3 | 7.88 | 8.11 | 7.33d | 8.11b-d | 8.55b | 8.22e |
| W4 | 7.44 | 8.00 | 8.11bc | 8.11b-d | 8.11c | 8.55cd |
| W5 | 8.00 | 7.77 | 8.22bc | 8.11b-d | 7.88cd | 8.33de |
| W6 | 7.66 | 8.11 | 8.66a | 8.77a | 9.00a | 9.55a |
| W7 | 7.55 | 7.44 | 7.88c | 8.66ab | 8.66ab | 9.11b |
| W8 | 7.44 | 7.77 | 7.77c | 7.88cd | 5.66e | 6.66f |
| W9 | 7.77 | 8.11 | 8.44ab | 8.22bc | 8.66ab | 9.00b |
| W10 | 7.88 | 7.88 | 8.11bc | 8.00cd | 7.88cd | 9.00b |
| W11 | 7.77 | 8.11 | 8.77a | 8.33a-c | 7.66d | 8.66c |
| W12 (Weedy check) | 7.55 | 7.55 | 7.33d | 7.55d | 5.66e | 8.00e |
| SE± | 0.107 | 0.171 | 0.070 | 0.085 | 0.066 | 0.053 |
| Interaction | | | | | | |
| V x W | NS | NS | ** | NS | NS | ** |

Means followed by the same letter(S) within the same column and treatment group are not statistically different (P>0.05) using Duncan Multiple Range Test (DMRT)

Key:
W1= Nicosulfuron 0.075 a.i./ha at 2 WAS only
W2= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W3= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W4= Nicosulfuron 0.15 a.i./ha at 2 WAS only
W5= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W6= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W7= Atrazine + Pendimethalin 2.0+2.0 a.i./ha at 2 WAS only
W8= Atrazine + Pendimethalin. 2.0+2.0 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W9= Atrazine + Pendimethalin 2.0+2.0 fb 0.075 at 2 WAS followed by Nicosulfuron at 5 WAS
W10= Atrazine 2.0 fb 0.075at 2 WAS followed by Nicosulfuron at 5 WAS
W11= Hoe weeding at 3 and 6 WAS
W12= Weedy check

Weed control treatment significantly (P<0.05) affected crop vigor score only at 12 WAS sampling period in 2016 wet season. Nicosulfuron (0.15 kg a.i./ha) at 2 WAS followed by Nicosulfuron (0.075 kg a.i./ha) at 5WAS (W6) and Hoe weeding at 3 and 6 WAS, (W11) produced the highest crop vigor score, they were statistically at par with Atrazine +

Pendimethalin (2.0 + 2.0 kg a.i./ha) followed by Nicosulfuron (0.075 kg a.i./ha) at 5 WAS (W9), however, weedy check produced the least crop vigor score.

At Maigana in 2017, SAMMAZ-29 produced the highest crop vigor score, but at 4 WAS, it was statistically at par with SAMMAZ-32. However, SAMMAZ-33 produced the least crop vigor score at all the sampling periods except at 8 WAS which was statistically similar to that recorded by SAMMAZ-32.

Weed control treatments significantly (P>0.05) affected crop vigor score at all the sampling periods. Nicosulfuron (0.15 kg a.i./ha) followed by Nicosulfuron (0.075 kg a.i./ha) (W6) at 5 WAS produced the highest crop vigor score at all the sampling periods but were statistically similar to that of W7 at 4 WAS and 8 WAS. However, weedy check produced the lowest crop vigor score at all the sampling periods.

Table 2.1: Shows interaction between variety and weed control treatment on crop vigour score at twelve weeks after sowing of three maize varieties at Maigana during 2016 wet season. SAMMAZ-29 with Nicosulfuron (0.075 Kg a.i./ha) at 2 WAS followed by Nicosulfuron at same rate and Atrazine + Pendimethalin (2.0 + 2.0) kg a.i./ha) followed by Nicosulfuron (0.075 kg a.i./ha) at 5 WAS produced the highest crop vigor score. But the three varieties produced the least crop vigor score with weedy check.

Table 2.1: Interaction between variety and weed control on crop vigor score at 12 WAS at Maigana, 2016 wet season

| Treatment<br>Weed control (W) | SAMMAZ-29 (V1) | SAMMAZ-32 (V2) | SAMMAZ-33 (V3) |
|---|---|---|---|
| W1 | 7.33h | 8.00d | 8.00d |
| W2 | 7.33h | 7.33h | 7.33h |
| W3 | 9.00a | 8.33c | 8.67b |
| W4 | 8.33c | 8.33c | 8.00d |
| W5 | 8.33c | 8.33c | 8.00d |
| W6 | 8.33c | 8.33c | 7.00f |
| W7 | 7.33h | 7.33h | 8.67b |
| W8 | 8.67b | 8.67b | 8.00d |
| W9 | 9.00a | 8.67b | 8.67b |
| W10 | 8.00d | 8.00d | 8.33c |
| W11 | 7.33h | 7.33h | 7.33h |
| W12 (Weedy check) | 6.33f | 6.33f | 6.67e |
| SE± | | 0.0906 | |

Means followed by the same letter(s) do not differ significantly (P>0.05) according to Duncan Multiple Range Test (DMRT)

Key:
W1= Nicosulfuron 0.075 a.i./ha at 2 WAS only
W2= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W3= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W4= Nicosulfuron 0.15 a.i./ha at 2 WAS only
W5= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W6= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W7= Atrazine +Pendimethalin 2.0+2.0 a.i./ha at 2 WAS only
W8= Atrazine +Pendimethalin. 2.0+2.0 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W9= Atrazine +Pendimethalin 2.0+2.0 fb 0.075 at 2 WAS followed by Nicosulfuron at 5 WAS

W10= Atrazine 2.0 fb 0.075at 2 WAS followed by Nicosulfuron at 5 WAS
W11= Hoe weeding at 3 and 6 WAS
W12= Weedy check

Table 2.2: shows interaction between variety and weed control treatments on crop vigor score at twelve weeks after sowing at Maigana during 2017 wet season. SAMMAZ-29 with Nicosulfuron (0.075 Kg a.i./ha) at 2 WAS followed by hoe weeding at 5 WAS and SAMMAZ-33 with Nicosulfuron (0.15 kg a.i./ha) followed by Nicosulfuron at the same rate and Hoe weeding (3 and 6 WAS) gave significantly higher crop vigor score. However, SAMMAZ-29 and SAMMAZ-32 with Atrazine + Pendimethalin (2.0 + 2.0 kg a.i./ha) only gave the least crop vigor score.

Table 2.2: Interaction between variety and weed control on crop vigor score at 12 WAS at Maigana, 2017 wet season

| Treatments | SAMMAZ-29 (V1) | SAMMAZ-32 (V2) | SAMMAZ-33 (V3) |
|---|---|---|---|
| Weed control (W) | | | |
| W1 | 9.00c | 8.00f | 7.66g |
| W2 | 9.00c | 7.00h | 8.66d |
| W3 | 8.66d | 9.00c | 8.00f |
| W4 | 8.00f | 8.00f | 9.00c |
| W5 | 10.00a | 9.00c | 8.33e |
| W6 | 9.00c | 9.66b | 10.00a |
| W7 | 6.00i | 6.00i | 8.00f |
| W8 | 7.00h | 8.00f | 9.00c |
| W9 | 9.00c | 9.00c | 9.00c |
| W10 | 8.00f | 9.00c | 9.00c |
| W11 | 9.00c | 8.00f | 10.00a |
| W12 (Weedy check) | 8.00f | 8.00f | 9.00c |
| SE± | | 0.0217 | |

Means followed by the same letter(s) do not differ significantly (P>0.05) according to Duncan multiple range test (DMRT)

Key:
W1= Nicosulfuron 0.075 a.i./ha at 2 WAS only
W2= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W3= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W4= Nicosulfuron 0.15 a.i./ha at 2 WAS only
W5= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W6= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W7= Atrazine +Pendimethalin 2.0+2.0 a.i./ha at 2 WAS only
W8= Atrazine +Pendimethalin. 2.0+2.0 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W9= Atrazine +Pendimethalin 2.0+2.0 fb 0.075 at 2 WAS followed by Nicosulfuron at 5 WAS
W10= Atrazine 2.0 fb 0.075at 2 WAS followed by Nicosulfuron at 5 WAS
W11= Hoe weeding at 3 and 6 WAS
W12= Weedy check

Varietal difference caused significant (P<0.05) influence at 12 WAS in 2016 and 4WAS in 2017 wet seasons (Table 3). In 2016 SAMMAZ-29 and 32 produced the highest

LAI than SAMMAZ-33. However, SAMMAZ-33 produced the highest LAI than SAMMAZ-29 and 32 at 4WAS in 2017.

Table 3: Relative growth rate of extra-early maize varieties as influenced by weed control treatments at Maigana, 2016 and 2017 wet Seasons in the Northern Guinea Savanna of Nigeria

| Variety (V) | 2016 | | 2017 | |
|---|---|---|---|---|
| | 8WAS | 12WAS | 8WAS | 12WAS |
| SAMMAZ-29 | 0.53a | 1.45 | 0.74a | 0.88a |
| SAMMAZ -32 | 0.59b | 0.50 | 0.68b | 0.81b |
| SAMMAZ -33 | 0.61b | 0.40 | 0.65b | 0.23c |
| SE± | 0.018 | 8.529 | 0.021 | 0.019 |
| Weed Control (W) | | | | |
| W1 | 0.60b | 0.30b | 0.72bc | 0.66a-c |
| W2 | 0.42e | 0.40b | 0.71bc | 0.67a-c |
| W3 | 0.60b | 0.50b | 0.60c | 0.61a-c |
| W4 | 0.58b-d | 0.79a | 0.66bc | 0.61a-c |
| W5 | 0.60b | 0.40b | 0.58c | 0.69ab |
| W6 | 0.74a | 0.50b | 0.87a | 0.72a |
| W7 | 0.64ab | 0.40b | 0.71bc | 0.58bc |
| W8 | 0.51c | 0.60b | 0.69bc | 0.67a-c |
| W9 | 0.48d | 0.60b | 0.64bc | 0.55c |
| W10 | 0.48d | 0.60b | 0.64c | 0.66a-c |
| W11 | 0.68ab | 0.40b | 0.78ab | 0.70ab |
| W12 (Weedy check) | 0.58b-d | 0.40b | 0.69bc | 0.58bc |
| SE± | 0.036 | 1.059 | 0.042 | 0.038 |
| Interaction | | | | |
| V x W | ** | NS | NS | NS |

Means followed by the same letter(S) within the same column and treatment group are not statistically different at 5% level of probability Using Duncan Multiple Range Test (DMRT)

Key:
W1= Nicosulfuron 0.075 a.i./ha at 2 WAS only
W2= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W3= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W4= Nicosulfuron 0.15 a.i./ha at 2 WAS only
W5= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W6= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W7= Atrazine +Pendimethalin 2.0+2.0 a.i./ha at 2 WAS only
W8= Atrazine +Pendimethalin. 2.0+2.0 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W9= Atrazine +Pendimethalin 2.0+2.0 fb 0.075 at 2 WAS followed by Nicosulfuron at 5 WAS
W10= Atrazine 2.0 fb 0.075at 2 WAS followed by Nicosulfuron at 5 WAS
W11= Hoe weeding at 3 and 6 WAS
W12= Weedy check

Table 4: Interaction between variety and weed control on Relative growth rate at eight weeks after sowing (8WAS) of three maize varieties at Maigana 2016 wet season

| Treatment | SAMMAZ-29 (V1) | SAMMAZ-32 (V2) | SAMMAZ-33 (V3) |
|---|---|---|---|
| Weed control (W) | | | |
| W1 | 0.43t | 0.60k | 0.38u |
| W2 | 0.66h | 0.72e | 0.65i |
| W3 | 0.58l | 0.55n | 0.67g |
| W4 | 0.55n | 0.68f | 0.53p |
| W5 | 0.76b | 0.75c | 0.72e |
| W6 | 0.74d | 0.52o | 0.53p |
| W7 | 0.72e | 0.62i | 0.58l |
| W8 | 0.55n | 0.41t | 0.57m |
| W9 | 0.64j | 0.54o | 0.26v |
| W10 | 0.41t | 0.57m | 0.46s |
| W11 | 0.77a | 0.47r | 0.42t |
| W12 (Weedy check) | 0.58l | 0.60k | 0.57m |
| SE± | | 0.023 | |

Means followed by the same letter(S) within the same column and treatment group are not statistically different at 5% level of probability Using Duncan Multiple Range Test (DMRT)

Key:
W1= Nicosulfuron 0.075 a.i./ha at 2 WAS only
W2= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W3= Nicosulfuron 0.075 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W4= Nicosulfuron 0.15 a.i./ha at 2 WAS only
W5= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W6= Nicosulfuron 0.15 a.i./ha at 2 WAS followed by Nicosulfuron at same rate at 5 WAS
W7= Atrazine +Pendimethalin 2.0+2.0 a.i./ha at 2 WAS only
W8= Atrazine +Pendimethalin. 2.0+2.0 a.i./ha at 2 WAS followed by Hoe Weeding at 5 WAS
W9= Atrazine +Pendimethalin 2.0+2.0 fb 0.075 at 2 WAS followed by Nicosulfuron at 5 WAS
W10= Atrazine 2.0 fb 0.075at 2 WAS followed by Nicosulfuron at 5 WAS
W11= Hoe weeding at 3 and 6 WAS
W12= Weedy check

Table 5 shows varietal difference, weed control treatments on grain yield/ha of maize at Maigana 2016 and 2017 wet season. Varietal difference significantly affected grain yield/ha in 2016 and the mean only. In 2016 and mean, SAMMAZ-29 produced the highest grain yield/ha but were statistically at par with SAMMAZ-32 in 2016 rainy season. Weed control treatment significantly affected grain yield/ha of maize in 2016, 2017 and mean Maigana. In 2016, W6, W8, W9 and Hoe weeding (W11) produced the highest grain yield/ha than the rest of the treatments, however, weedy check produced the least yield/ha. But, in 2017, W6 produced the highest yield/ha than the rest of the treatment combination. Which in the mean, W6 produced the highest yield/ha but were statistically at par with the rest of the treatments except W1, W4, W5, W7, W9, W10 and W12, however, weedy check produced the least grain yield (kg/ha).

Table 5: Yield/ha (kg) of extra-early maize (*Zea mays* L.) Varieties as influenced by weed control treatments at Maigana during 2016 and 2017 wet Seasons in the northern guinea Savanna of Nigeria

| Treatments | | 2016 | 2017 | Mean |
|---|---|---|---|---|
| Variety(V) | | | | |
| SAMMAZ-29 | | 1007.28a | 1515.81 | 750.26a |
| SAMMAZ -32 | | 927.50ab | 1445.01 | 353.77c |
| SAMMAZ -33 | | 857.92b | 1397.65 | 596.40b |
| SE± | | 42.138 | 56.036 | 61.8012 |
| Weed control (W) | kga.i/ | | | |
| (W1) | 0.075 | 461.80d | 1423.30cd | 544.0b-e |
| (W2) | 0.075 | 529.7cd | 1600.9c | 704.5a-c |
| W3 | 0.075 | 412.6d | 1197.2d | 665.3a-c |
| W4 | (0.l5 | 572.3cd | 766.2e | 426.0c-e |
| W5 | (0.l5 | 458.6d | 2278.7b | 587.2b-d |
| W6 | (0.l5 | 1804.7a | 3680.2a | 874.0a |
| W7 | 2.0+2.0 | 555.8cd | 387.8f | 289.8e |
| W8 | 2.0+2.0 | 1726.8a | 1441.6cd | 677.7a-c |
| W9 | 2.0+2.0 fb 0.075 | 1908.3a | 1116.5d | 373.6de |
| W10 | 2.0 fb 0.075 | 513.8cd | 524.6ef | 600.4b-d |
| W11 | | 1484.8a | 2508.6b | 776.6ab |
| W12 (Weedy check) | | 741.8c | 508.3ef | 282.6e |
| SE± | | 84.276 | 112.072 | 123.602 |
| Interaction | | | | |
| W x V | | NS | NS | NS |

Means followed by the same letter(S) within the same column and treatment group are not statistically different at 5% level of probability Using Duncan Multiple Range Test (DMRT)

## DISCUSSION

The study was conducted at Maigana during 2016 and 2017 Rainy seasons to evaluate the selectivity of pre-emergence and post-emergence herbicides on three extra-early maize varieties. It was observed that the maximum yield of maize obtained in 2016 at Maigana was 1804.7kg/ha, while that of maize in Maigana in the corresponding year (2017) was 3680.2kg/ha respectively. The percentage (%) increase in the grain yields of maize in 2017 over that of maize yield in 2016 at Maigana was 67%. This could be attributed to the incidence of stem borer infestation in 2016 rainy season in both locations, secondly, it also could be attributed to heavy rainfall experienced shortly after the application of herbicides in Maigana 2016 might have washed off and leached the herbicides beyond their action zone which reduced the phytotoxic effect of the applied herbicides treatments on weeds. That is why herbicides should not be applied shortly in anticipation of rainfall within 2-2-4 hours of application, so as to avoid wash off and leaching down of the chemical. Das (2008), reported that heavy rainfall may wash of both foliar-active as well as soil-active herbicides and promote their loss and reserve selectivity. Thirdly, it could also be probably due to differences in the soil nutrients, amount and distribution of rainfall, planting time and rainfall establishment during the growing seasons which influenced the herbicides on weeds in favor of the final crop yields obtained.

The application of Nicosultion (0.075 kg a.i./ha and 0.15 kg a.i./ha), Atrazine + Pendimethalin (2.0 + 2.0 kg a.i./ha) each applied alone and followed by hoe weeding at (5 WAS) or followed by Nicosultion (0.075 kg a.i./ha) at 5 WAS had significantly reduced weed cover score and weed dry weight. This observation could be attributed to the fact that the herbicides and supplementary hoe weeding inhibit the photosynthesis of the susceptible weed plant species and effective control of annual grasses that escaped herbicide treatments. This was in line with the findings of (Anon, 1994) who reported that pre-emergence application of herbicides (primextra-gold) at 2.0 kg a.i./ha followed by hoe weeding at 3 and 6 WAS effectively controlled *Rottboelia cochinchimensis* in maize. Magaji (1994) reported that pre-emergence application of herbicides (atrazine) at 2.0 kg a.i./ha followed by hoe weeding at 6 WAS controlled broad level and annual grass in maize. Similarly, Ishaya (1997) reported that application of Sulfonyl urea herbicides resulted in reduction of weed infestation in maize and rice. Also, some weed species like *Rottboelia cochinchimensis* that caused serious yield reduction in maize can only be easily controlled by pre-emergence application of sulfonyl urea herbicides and supplementary hoe weeding (Anon, 1994). The weeding check had that highest weed cover score and weed dry weight since no weed control measure was applied throughout the crop life cycle.

The growth of maize as reflected in the crop vigor score, leaf area index, relative growth rate, were all affected by weed control treatment and supplementary hoe weeding. The application of nicosulfuron at double recommended, followed by nicosulfuron at recommended each at 0.15 kg a.i./ha and 0.075 kg a.i./ha respectively, and hoe weeding at 3 and 6 WAS had increased crop vigor score, leave area index, crop growth rate, relative growth rate, this observed increase in growth parameters by weed control treatments and supplementary hoe weeding could be as a result of effective weed control of the treatments which had reduced the level of competition for growth resources such as light, nutrients and water by maize crops. This observation also could be due to effective weed control that allowed the crop grow and develop more and larger leaves which resulted in higher light interception, thereby accumulating higher dry matter per plant per unit area. This finding agrees with earlier observation by Magaji (1994), who reported that, application of pre-emergence herbicides at 1.29 kg a.i./ha and supplementary hoe weeding at 6 WAS resulted in high crop vigor score, crop growth rate, relative growth rate as well as plant height of maize. Also (Anon, 1994) reported that, pre-emergence application of herbicides at 3.0 kg a.i./ha and supplementary hoe weeding at 6 WAS resulted in high crop vigor score, crop growth rate and plant height of maize. The weeding check resulted in the reduction of these growth parameters throughout the experimental periods. This may be probably due to severe weed interference which resulted in serious competition between maize plant and uncontrolled weeds which led to drastic reduction in growth and development of the crop. Several researchers have reported reduction in growth parameters due to uncontrolled weeds in the weedy check (Ishaya, 1997).

The performance of the treatments combination as compared to the weedy check could be attributed to adequate weed suppression which allowed greater efficiency in the use of available growth resources such as light, water and nutrients. This is in line with the findings of Atangs, (1997), who reported that, yield increased when the crop was free from the weeds during its critical periods of weed interference which reported to be about 40 days after emergence in maize. Anon (1994) reported that, pre-emergence application of herbicides at 4.0 kg a.i./ha followed by hoe weeding at 6 WAS gave high yield of maize and rice. Also reported that pre-emergence application of herbicide at 2.5 kg a.i./ha followed by hoe weeding at 6 WAS and 9 WAS resulted in significant increase of maize grain yield compared to hoe weeded control. Magaji (1994) reported that pre-emergence application of herbicides followed by hoe weeding at 6 WAS resulted in high grain yield of maize. Ishaya (2004) also reported that, the application of cinosulfuron at 0.04 kg a.i./ha and prosulfuron at 0.08 kg a.i./ha resulted in high grain yield of maize and rice which was comparable to hoe weeded control. Also, the result is in conformity with that of Attangs (1997) who reported that application of sulfonylurea herbicides at 0.03 kg a.i./ha gave high yield of maize and rice, better growth and effective weed control.

## CONCLUSION

Based on the results obtained in this study, it could be concluded that, SAMMAZ-29 and SAMMAZ-32 with the application of Nicosulfuron at the rate of 0.15 kg a.i./ha at 2 WAS, followed by the application of Nicosulfuron at the rate of 0.075kg a.i./ha at 5 WAS proved to be the best combinations of variety and weed control methods and are hereby recommended for adoption by maize farmers for higher yields and control of weeds in the Northern Guinea Savannah ecological zone of Nigeria.

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