

# Comparative assessment of the effect of three plant spacing on the performance of early and late maize (*Zea mays* L.) varieties cultivated in the Humid tropics, Port Harcourt, Rivers State

## Abstract

Experiments were conducted in the late (dry) season and early (wet) season to determine the comparative growth response of maize varieties using various plant densities (spacings) at the Rivers State University Teaching and Research Farm Port Harcourt. The treatments consisted of four maize varieties (Bendel white, Oba super 6, Oba super 98 and Provit A) and three plant densities/spacings (60cm x 15cm, 60cm x 30cm, 60cm x 45cm). Treatments were combined in a split plot arrangement with maize varieties fitted in a Randomized Complete Block Design (RCBD) replicated three times. Parameters evaluated were plant height, leaf area, and number of leaves at 4, 6, and 8 weeks after planting (WAP). Insect infestation and stem girth were determined 8 weeks after planting. Results show that Provit A produced highest performance ( $P < 0.05$ ) in early (wet) season cropping in terms of plant height (70.2cm), number of leaves (9.3), leaf area (304.9cm). Bendel white was high in stem girth (7.8cm). Comparing growth in late (dry) season and early (wet) season showed that growth was better in the early (wet) season cropping. However, there was more insect infestation in the late (dry) season cropping than in the early (wet) season cropping. Oba super 6 had the highest incidence of insect pest infestation in late (dry) season cropping with a mean of 7.3%. Also spacing of 60cm x 30cm produced highest growth performance. Thus, Provit A is recommended for cultivation by farmers in Port Harcourt agroecological zone. Spacing of 60cm x 30cm is recommended for maize production in Port Harcourt agroecological zone.

**Keywords:** Varieties, spacing, season, growth performance

## 1.0 INTRODUCTION

Maize (*Zea mays* L.) popularly referred to as 'Corn or queen of cereals' is an important cereal crop belonging to the plant family Poaceae (Dhaka *et al.*, 2010; Kumar *et al.*, 2012). FAO (2002) reported that maize ranks third after wheat and rice in the world and also ranks second in terms of most cultivated crop (5.8million ha) after cassava in Nigeria (FAOSTAT, 2014). In Africa, South Africa is the highest producers of maize followed by Nigeria with production quantity of approximately 10.8 million metric tons in 2019 and 11.6 million metric tons in 2020 (FAOSTAT, 2014; FAO, 2021).

The regions of the world for maize production ranges from tropics, subtropics and temperate climate but grows best in regions with annual rainfall of 600-1000mm and pH level of 5.5 - 6.5 (Sprague and Dudley, 1988) and survives for only one growing season attaining a height of 2-4m (Akpan *et al.*, 2021). It is an annual, tall, determinate with narrow opposing leaves alternating along the stem length (Kumar *et al.*, 2012). Maize possess thick stem of 3-4cm and 20 internodes, the leaves are linear or lance-like with an evident midrib and can develop in length from 30-100cm (11.8 - 39.4inches). The male inflorescence (tassel) and female inflorescences (ear) are arranged separately on the plant while the kernel is sheathed in husks and their color ranges from white, yellow, red, purple or black. The roots of maize include seminal root, adventitious roots or fibrous root and brace or prop root (Kumar *et al.*, 2012).

In spite of the high significance of maize plant to man and animals, maize production has experienced rapid decline which can be attributed to inability to identify high yielding variety, low soil fertility, inappropriate plant spacing, planting date, low management, severe infection

and infestation by disease, weed and pests, poor cultural practices and inappropriate field operation (Fayenisin, 1993; Kim, 1997; Assefa, 1998; DIPA, 2006; Zeidan *et al.*, 2006; Enujeke, 2013). The lack of suitable planting date adversely affects grain yield and yield components, increase day to flowering, reduced dry matter production, decrease in number of seeds per cob (Buriro *et al.*, 2015; Kamara *et al.*, 2020; Rabbani and Safdary, 2021).

The suggested maize spacing varies from varieties to varieties depending on plant height and maturity. Thus, various researchers have recommended the use of 80cm × 20cm (Ukonze *et al.*, 2016), 60cm × 60cm (Khubna *et al.*, 2021) and 60cm × 15cm (Zamir *et al.*, 2011; Ramhari *et al.*, 2020). This research is therefore aimed at comparing the growth performance of the varieties as influenced by different intra-row and inter-row spacing.

## **2.0 MATERIALS AND METHODS**

### **2.1 Study Area**

The maize evaluation site was at the Rivers State University Teaching and Research farm, Port Harcourt. The experiment site is in the humid forest zone with mean annual rainfall of about 2400mm distributed March to November. Temperatures range from 27°C to 33°C and humidity is about 82-83% and at a peak of about 89% from July to September. The late season maize cultivated September to December 2023 while the early (wet) season maize was cultivated from April to July 2024.

### **2.2 Sources of Experimental materials**

The three hybrid maize varieties were obtained from the International Institute of Tropical Agriculture (IITA), Onne Station, Rivers State and Premier Seeds Nigeria Limited whereas the local variety was obtained from the local farmers.

### **2.3 Experimental materials/treatments**

The four varieties (3 hybrids and 1 local/landrace) that were used in this study are;

- a. Oba super 98
- b. Pro-vitamin A
- c. Oba super 6
- d. Bendel white

The three plant spacings are.

- a. 60cm x 15cm
- b. 60cm x 30cm
- c. 60cm x 45cm

### **2.4 Experimental Design**

The four maize varieties using three plant spacing were planted in split plot arrangement fitted into a Randomized Complete Block Design (RCBD). The maize varieties were allotted the main plots while the spacings were allotted the subplots. The Bendel white maize variety is a local variety that would be a type of control. There were three (3) replicates or blocks with the four maize varieties using each of the three plant populations in each replicate that resulted to twelve (12) plots and each plot was 6m<sup>2</sup> in a replicate.

### **2.5 Land Preparation / Planting and Establishment.**

The area was manually cleared and plots of 6m<sup>2</sup> were made into beds with furrows of 1 meter in between plots to avoid treatment interaction, enable water drainage and ensure easy access within the study area. The four maize varieties were planted using the three plant densities (60cm by 15cm, 60cm by 30cm and 60cm by 45cm) in each of the three replicates. Two maize seeds were planted per planting hole and thinned to one stand after germination in each plot of 6m<sup>2</sup>. Each replicate would have twelve (12) plots with a total of 36 treatment combinations covering an area of 16m by 16m. Thus, the respective plant populations were 111,111 (60cm by 15cm), 55,555 (60cm by 30cm) and 37,037 (60cm by 45cm) stands per hectare. Planting was done in early and late season.

## **2.6 Growth parameters evaluated**

### **a) Plant height**

A measuring tape was used to measure the height of the maize plants from the surface of the soil to the tip of the central spike tassel at 4, 6, and 8 weeks after planting. The height of 10 plants were taken from each plot and the average used to represent that treatment. The measurements were recorded in centimetres (cm).

### **b) Number of Leaves**

The number leaves were counted directly from five (5) maize stands per plot at 4, 6, and 8 weeks after planting.

### **c) Leaf area**

Ten leaves from ten randomly selected maize plants in each plot were measured at the fourth leaf from the top of the plant, because it is fully expanded. Maximum length and width of the leaf were determined using measuring tape to obtain the leaf area. The maize leaf area was computed by multiplying the maximum length of leaf multiplied by maximum width and the leaf coefficient (correction coefficient of 0.75) according to Akpan *et al.* (2021).

$$LA = 0.75 LW$$

### **d) Stem girth**

Stem girth was measured with measuring tape at 8 weeks after planting in each plot

### **e) Insect Infestation**

Infestation of each plot by insects was assessed visually at 8 weeks after planting and recorded in percentage.

## **2.7 Weed Control**

Weeding was done manually as first weeding was done three weeks after planting and second weeding six weeks after planting.

## **2.8 Data Analysis**

Data was collected from the field at two, four and eight weeks after planting and arranged in excel spread sheet. Analysis of data was done using Minitab software and significant means were separated using Tukey's Pairwise comparison grouping method (Minitab, 2019).

## **3.0 RESULTS**

Results from the experimental study in Table 1 showed that  $V_4 + SP_1$  (30.7cm) had the highest mean plant height followed by  $V_4 + SP_2$  (30.4cm) and the lowest was  $V_1 + SP_3$  (14.8cm) in 4WAP.  $V_4 + SP_3$  had high mean plant height values of 61.6cm in 6WAP and  $V_2 + SP_2$  (129.1cm) in 8WAP whilst the least was observed in  $V_1 + SP_3$  (34.5cm and 67.3cm) respectively. Table 1 also revealed that  $V_2 + SP_1$  and  $V_3 + SP_1$  was higher ( $P>0.05$ ) in number of leaves with mean value of 7.9 and lowest in  $V_1 + SP_1$  and  $V_1 + SP_3$  (6.3). In 6WAP, the highest number of leaves was recorded in  $V_4 + SP_3$  (10.2) followed by  $V_3 + SP_1$  (9.8).  $V_2 + SP_2$  had high ( $P>0.05$ ) number of leaves in 8WAP. However, there was no significant difference between the treatments in number of leaves across the sampled weeks but mean differences.

The combined effect between variety and spacing revealed that  $V_4 + SP_2$  was significantly higher with a mean value of 151.3, followed by  $V_4 + SP_3$  (148.4) in 4WAP. At 6WAP and 8WAP, the highest mean leaf area was observed in  $V_4 + SP_3$  (469.6 and 428.1) respectively (Table 2). Interactions in stem girth showed that  $V_1 + SP_2$  had high mean value ( $P>0.05$ ) of 7.5cm followed by  $V_4 + SP_3$  (7.1cm) and least was  $V_2 + SP_1$  (5.6cm). There was indifference significantly between the treatments in stem girth. Result on insect infestation showed that there was significant difference between the treatments with  $V_2 + SP_2$  having the highest infestation rate of 5.2% and  $V_2 + SP_3$  having the lowest infestation rate of 2.2% (Table 2).

Furthermore, the interactive effect of variety and season clearly showed that Provit A variety was higher in plant height (101.8cm), number of leaves (10.4) and leaf area (353.0) in wet season while Bendel white variety was lowest in plant height (77.9cm), number of leaves (9.9) and leaf area (310.8) respectively. In dry season, Provit A variety produced high plant height (38.7cm), number of leaves (8.4) and leaf area (256.7) whilst Bendel white variety had the least mean value of plant height (20.8cm), number of leaves (7.0) and leaf area (159.3) (Table 3).

Table 4 revealed that Bendel white variety had the highest stem girth and insect infestation rate of 8.1cm and 2.3% in wet (early) season whereas in dry (late) season, Bendel white variety had the highest insect infestation rate of 6.1% and Provit A variety, Bendel white variety had high mean value of 6.2cm in stem girth.

Result on the interaction of varieties, spacing and season in Table 5 revealed that  $V_4 + SP_2 +$  wet season had the highest mean plant height of 47.2cm followed by  $V_4 + SP_1 +$  wet season (45.0cm) in 4WAP.  $V_3 + SP_2 +$  wet season was significantly higher in 6WAP with mean height of 92.0cm and the lowest was  $V_1 + SP_3 +$  dry season (11.6cm). At 8WAP, it was observed that  $V_4 + SP_2 +$  wet had high mean plant height of 186.1cm but was not significantly different from plant height obtained from  $V_2 + SP_2 +$  wet season (178.2cm) respectively. Also, table 5 showed that  $V_2 + SP_1 +$  wet season and  $V_3 + SP_1 +$  wet season (8.9) had the highest number of leaves at 4WAP and lowest was recorded in  $V_1 + SP_2 +$  dry season (4.7) respectively.  $V_1 + SP_2 +$  wet season (11.4 and 14.1) were higher ( $P>0.05$ ) in number of leaves in 6WAP and 8WAP whilst the least mean value was recorded in  $V_1 + SP_3 +$  dry season (6.8 and 7.4). There was no significant difference between the treatments in number of leaves across the studied weeks (4WAP – 8WAP) but mean differences.

The combined effect on leaf area clearly showed that  $V_3 + SP_2 +$  wet (221.0) was higher ( $P>0.05$ ) followed by  $V_3 + SP_3 +$  wet (205.5) and low in  $V_1 + SP_3 +$  dry (26.7) in 4WAP. At 6WAP,  $V_4 + SP_3 +$  dry had high mean value ( $P<0.05$ ) of 518.0 and the least was noted in  $V_1 + SP_3 +$  dry (108.0) respectively. At 8WAP, the highest leaf area was recorded in  $V_1 + SP_2 +$  wet (479.8), followed by  $V_3 + SP_2 +$  wet (477.0) and lowest was  $V_1 + SP_3 +$  dry (231.3) (Table 6).

V<sub>1</sub> + SP<sub>2</sub> + wet had high mean stem girth of 9.6 followed by V<sub>1</sub> + SP<sub>3</sub> + wet (7.9) while the least mean was recorded in V<sub>3</sub> + SP<sub>2</sub> + dry (5.1) respectively. Table 6 also revealed that V<sub>1</sub> + SP<sub>2</sub> + dry was significantly higher (P<0.05) with mean value of 8.0% followed by V<sub>4</sub> + SP<sub>2</sub> + dry (7.0%) whereas the lowest infestation rate was in V<sub>4</sub> + SP<sub>3</sub> + wet (1.0%).

Varietal influence on plant height illustrated in Fig. 1 revealed that Provit A variety had the highest mean of 29.7cm, 59.1cm and 121.9cm across the weeks and lowest was Bendel white variety (19.6cm, 41.8cm and 91.6cm) but there was no significant difference between (P>0.05) OBA super 6 and OBA super 98 varieties respectively. In leaf number, Provit A variety was significantly higher. Although, no significant difference was recorded in varieties OBA super 98, OBA super 6 and Bendel white but mean difference respectively (Fig 2). Fig.3 showed that Provit A had high (P<0.05) leaf area value of 147.8cm, 374.2cm and 392.6cm across the sampled weeks and least was Bendel white variety respectively. Similarly, varietal response on stem girth showed that Bendel white variety had wide stem girth of 7.5cm and lowest was noted in OBA super 6 and OBA super 98 varieties (6.2cm) (Fig. 4). OBA super 6 variety (5.4%) was significantly higher, followed by Bendel white variety (5.3%), OBA super 98 variety (4.6%) and Provit A (3.9%) in insect infestation respectively (Fig. 5).

Plant density response revealed that 60cm x 30cm produced the highest plant height (26.4cm, 54.3cm, 119.1cm) across the sampled weeks (4WAP-8WAP) followed by 60cm x 15cm plots (26.3cm, 51.6cm, 108.7cm) and the lowest was observed from 60cm x 45cm plots (22.6cm, 45.9cm, 96.1cm) (Fig. 6). There was no significant difference between the different sampled plant densities in leaf number but mean differences with 60cm x 15cm having the highest mean value of 7.4, 9.4 and 10.6 in 4WAP – 8WAP (Fig. 7). 60cm x 30cm was highest in leaf area (123.4cm and 396.3cm) in 4WAP and 8WAP and 60cm x 15cm had high leaf area in 6WAP (Fig. 8). Also, 60cm x 30cm had high mean stem girth (P>0.05) of 6.7cm followed by 60cm x 45cm (6.6cm) and least was observed in 60cm x 15cm plots (6.2) respectively (Fig. 9). In insect infestation, 60cm x 30cm was significantly higher (P<0.05) and the lowest was 60cm x 45cm plots (Fig. 10).

Seasonal effect on plant height showed that wet (early) season cropping produced the highest mean values (P<0.05) of 93.9cm, 10.2 and 329.4 in plant height, number of leaves and leaf area compared to dry (late) season cropping (30.7cm, 7.8, 201.9) (Fig. 11). Wet season was significantly higher in mean stem girth while dry season had higher mean values (P<0.05) in insect infestation rate as illustrated in Fig. 12.

**Table 1: Effect of spacing on the plant height and number of leaves of the studied varieties**

Treatments	Plant height (cm)			Number of leaves		
	4WAP	6WAP	8WAP	4WAP	6WAP	8WAP
V <sub>1</sub> + SP <sub>1</sub>	19.8 <sup>b</sup>	42.3 <sup>c</sup>	89.7 <sup>c</sup>	6.3 <sup>a</sup>	9.5 <sup>a</sup>	10.5 <sup>a</sup>
V <sub>1</sub> + SP <sub>2</sub>	21.2 <sup>b</sup>	47.3 <sup>c</sup>	107.2 <sup>b</sup>	6.5 <sup>a</sup>	9.1 <sup>a</sup>	11.0 <sup>a</sup>
V <sub>1</sub> + SP <sub>3</sub>	14.8 <sup>b</sup>	34.5 <sup>c</sup>	67.3 <sup>c</sup>	6.3 <sup>a</sup>	7.8 <sup>a</sup>	9.3 <sup>a</sup>
V <sub>2</sub> + SP <sub>1</sub>	28.7 <sup>a</sup>	54.2 <sup>b</sup>	112.7 <sup>b</sup>	7.9 <sup>a</sup>	9.3 <sup>a</sup>	10.2 <sup>a</sup>
V <sub>2</sub> + SP <sub>2</sub>	27.1 <sup>a</sup>	55.0 <sup>b</sup>	129.1 <sup>ab</sup>	7.4 <sup>a</sup>	9.2 <sup>a</sup>	11.6 <sup>a</sup>
V <sub>2</sub> + SP <sub>3</sub>	25.3 <sup>b</sup>	43.9 <sup>c</sup>	107.6 <sup>b</sup>	7.2 <sup>a</sup>	8.6 <sup>a</sup>	10.4 <sup>a</sup>
V <sub>3</sub> + SP <sub>1</sub>	26.1 <sup>ab</sup>	53.5 <sup>b</sup>	117.5 <sup>b</sup>	7.9 <sup>a</sup>	9.8 <sup>a</sup>	11.0 <sup>a</sup>
V <sub>3</sub> + SP <sub>2</sub>	27.0 <sup>ab</sup>	55.5 <sup>b</sup>	111.9 <sup>b</sup>	6.6 <sup>a</sup>	8.8 <sup>a</sup>	10.0 <sup>a</sup>
V <sub>3</sub> + SP <sub>3</sub>	22.2 <sup>b</sup>	43.5 <sup>c</sup>	86.5 <sup>c</sup>	6.9 <sup>a</sup>	8.6 <sup>a</sup>	10.3 <sup>a</sup>

V <sub>4</sub> + SP <sub>1</sub>	30.7 <sup>a</sup>	56.4 <sup>a</sup>	114.8 <sup>ab</sup>	7.4 <sup>a</sup>	9.1 <sup>a</sup>	10.8 <sup>a</sup>
V <sub>4</sub> + SP <sub>2</sub>	30.4 <sup>a</sup>	59.3 <sup>a</sup>	128.1 <sup>a</sup>	7.6 <sup>a</sup>	9.3 <sup>a</sup>	11.1 <sup>a</sup>
V <sub>4</sub> + SP <sub>3</sub>	28.1 <sup>a</sup>	61.6 <sup>a</sup>	122.9 <sup>a</sup>	7.6 <sup>a</sup>	10.2 <sup>a</sup>	11.2 <sup>a</sup>

\*Means that do not share a letter are significantly different at 5% probability level

#### KEY

V - varieties, SP - spacing, V<sub>1</sub> – Bendel white, V<sub>2</sub> - OBA 6, V<sub>3</sub> - OBA 98, V<sub>4</sub> - PROVIT A, SP<sub>1</sub> - 60cm × 15cm, SP<sub>2</sub> - 60cm × 30cm, SP<sub>3</sub> - 60cm × 45cm, WAP - Weeks after planting.

**Table 2: Effect of spacing on leaf area, stem girth and insect infestation of four studied maize varieties**

Treatments	Leaf area			Stem girth (cm)	Insect infestation
	4WAP	6WAP	8WAP		
V <sub>1</sub> + SP <sub>1</sub>	75.7 <sup>c</sup>	271.1 <sup>c</sup>	369.7 <sup>b</sup>	7.0 <sup>a</sup>	3.3 <sup>bc</sup>
V <sub>1</sub> + SP <sub>2</sub>	109.0 <sup>b</sup>	273.7 <sup>c</sup>	399.4 <sup>ab</sup>	7.5 <sup>a</sup>	5.2 <sup>a</sup>
V <sub>1</sub> + SP <sub>3</sub>	57.6 <sup>c</sup>	223.5 <sup>c</sup>	335.6 <sup>b</sup>	6.8 <sup>a</sup>	4.2 <sup>b</sup>
V <sub>2</sub> + SP <sub>1</sub>	120.8 <sup>b</sup>	309.1 <sup>bc</sup>	352.2 <sup>b</sup>	5.6 <sup>a</sup>	2.7 <sup>c</sup>
V <sub>2</sub> + SP <sub>2</sub>	112.5 <sup>b</sup>	321.5 <sup>bc</sup>	420.3 <sup>a</sup>	6.5 <sup>a</sup>	3.5 <sup>bc</sup>
V <sub>2</sub> + SP <sub>3</sub>	100.2 <sup>b</sup>	253.5 <sup>c</sup>	384.1 <sup>b</sup>	6.2 <sup>a</sup>	2.2 <sup>c</sup>
V <sub>3</sub> + SP <sub>1</sub>	109.3 <sup>b</sup>	305.2 <sup>bc</sup>	370.5 <sup>b</sup>	6.1 <sup>a</sup>	3.7 <sup>bc</sup>
V <sub>3</sub> + SP <sub>2</sub>	120.9 <sup>b</sup>	280.9 <sup>bc</sup>	372.7 <sup>b</sup>	6.1 <sup>a</sup>	4.0 <sup>b</sup>
V <sub>3</sub> + SP <sub>3</sub>	85.8 <sup>c</sup>	254.8 <sup>c</sup>	348.9 <sup>b</sup>	6.5 <sup>a</sup>	3.3 <sup>bc</sup>
V <sub>4</sub> + SP <sub>1</sub>	143.7 <sup>a</sup>	322.3 <sup>b</sup>	356.8 <sup>b</sup>	5.9 <sup>a</sup>	3.0 <sup>bc</sup>
V <sub>4</sub> + SP <sub>2</sub>	151.3 <sup>a</sup>	330.6 <sup>b</sup>	392.9 <sup>ab</sup>	6.7 <sup>a</sup>	4.8 <sup>b</sup>
V <sub>4</sub> + SP <sub>3</sub>	148.4 <sup>a</sup>	469.6 <sup>a</sup>	428.1 <sup>a</sup>	7.1 <sup>a</sup>	2.3 <sup>c</sup>

\*Means that do not share a letter are significantly different at 5% probability level

#### KEY

V - varieties, SP - spacing, V<sub>1</sub> – Bendel white, V<sub>2</sub> - OBA 6, V<sub>3</sub> - OBA 98, V<sub>4</sub> - PROVIT A, SP<sub>1</sub> - 60cm × 15cm, SP<sub>2</sub> - 60cm × 30cm, SP<sub>3</sub> - 60cm × 45cm, WAP - Weeks after planting.

**Table 3: Effect of variety and season on plant height, number of leaves and leaf area**

Variety	Season	Plant height (cm)	No of leaves	Leaf area (cm)
Bendel white	Wet	77.9 <sup>b</sup>	9.9 <sup>a</sup>	310.8 <sup>a</sup>
	Dry	20.8 <sup>c</sup>	7.0 <sup>a</sup>	159.3 <sup>c</sup>
OBA 6	Wet	95.5 <sup>ab</sup>	10.2 <sup>a</sup>	317.0 <sup>a</sup>
	Dry	34.1 <sup>c</sup>	7.9 <sup>a</sup>	210.6 <sup>bc</sup>
OBA 98	Wet	100.3 <sup>a</sup>	10.4 <sup>a</sup>	336.8 <sup>a</sup>
	Dry	29.1 <sup>c</sup>	7.7 <sup>a</sup>	180.9 <sup>c</sup>
Provit A	Wet	101.8 <sup>a</sup>	10.4 <sup>a</sup>	353.0 <sup>a</sup>
	Dry	38.7 <sup>c</sup>	8.4 <sup>a</sup>	256.7 <sup>b</sup>

\*Means that do not share a letter are significantly different at 5% probability level

**Table 4: Effect of variety and season on stem girth and insect infestation**

Variety	Season	Stem girth (cm)	Insect infestation (%)
Bendel white	Wet	8.1 <sup>a</sup>	2.3 <sup>c</sup>
	Dry	6.2 <sup>b</sup>	6.1 <sup>a</sup>
OBA 6	Wet	6.7 <sup>b</sup>	1.9 <sup>c</sup>
	Dry	5.5 <sup>b</sup>	3.7 <sup>a</sup>
OBA 98	Wet	6.7 <sup>b</sup>	2.0 <sup>c</sup>
	Dry	5.8 <sup>b</sup>	5.4 <sup>a</sup>
Provit A	Wet	6.9 <sup>b</sup>	1.7 <sup>c</sup>

Dry

6.2<sup>b</sup>5.1<sup>b</sup>

\*Means that do not share a letter are significantly different at 5% probability level

**Table 5: Effect of season and spacing on plant height and number of leaves of four studied maize varieties**

Treatment	Season	Plant height			No of leaves		
		4WAP	6WAP	8WAP	4WAP	6WAP	8WAP
V <sub>1</sub> + SP <sub>1</sub>	Dry	7.3 <sup>d</sup>	21.0 <sup>d</sup>	52.2 <sup>fg</sup>	5.2 <sup>a</sup>	9.8 <sup>a</sup>	9.6 <sup>a</sup>
	Wet	32.3 <sup>b</sup>	63.7 <sup>c</sup>	127.2 <sup>c</sup>	7.4 <sup>a</sup>	9.2 <sup>a</sup>	11.5 <sup>a</sup>
V <sub>1</sub> + SP <sub>2</sub>	Dry	6.9 <sup>d</sup>	14.7 <sup>d</sup>	42.5 <sup>g</sup>	4.7 <sup>a</sup>	6.9 <sup>a</sup>	7.9 <sup>a</sup>
	Wet	35.5 <sup>b</sup>	79.8 <sup>b</sup>	17.0 <sup>h</sup>	8.3 <sup>a</sup>	11.4 <sup>a</sup>	14.1 <sup>a</sup>
V <sub>1</sub> + SP <sub>3</sub>	Dry	6.2 <sup>d</sup>	11.6 <sup>d</sup>	24.7 <sup>h</sup>	5.2 <sup>a</sup>	6.8 <sup>a</sup>	7.4 <sup>a</sup>
	Wet	23.3 <sup>c</sup>	57.5 <sup>c</sup>	109.8 <sup>d</sup>	7.3 <sup>a</sup>	8.8 <sup>a</sup>	11.3 <sup>a</sup>
V <sub>2</sub> + SP <sub>1</sub>	Dry	12.6 <sup>d</sup>	25.8 <sup>d</sup>	60.4 <sup>f</sup>	6.8 <sup>a</sup>	7.8 <sup>a</sup>	9.1 <sup>a</sup>
	Wet	44.8 <sup>a</sup>	82.7 <sup>a</sup>	165.1 <sup>b</sup>	8.9 <sup>a</sup>	10.7 <sup>a</sup>	11.3 <sup>a</sup>
V <sub>2</sub> + SP <sub>2</sub>	Dry	15.5 <sup>c</sup>	32.4 <sup>d</sup>	80.1 <sup>e</sup>	6.9 <sup>a</sup>	8.3 <sup>a</sup>	10.2 <sup>a</sup>
	Wet	38.7 <sup>ab</sup>	77.7 <sup>b</sup>	178.2 <sup>a</sup>	7.9 <sup>a</sup>	10.1 <sup>a</sup>	13.1 <sup>a</sup>
V <sub>2</sub> + SP <sub>3</sub>	Dry	11.5 <sup>d</sup>	20.9 <sup>d</sup>	48.3 <sup>g</sup>	6.2 <sup>a</sup>	7.6 <sup>a</sup>	8.3 <sup>a</sup>
	Wet	39.1 <sup>a</sup>	66.8 <sup>c</sup>	166.8 <sup>b</sup>	8.1 <sup>a</sup>	9.5 <sup>a</sup>	12.5 <sup>a</sup>
V <sub>3</sub> + SP <sub>1</sub>	Dry	11.0 <sup>d</sup>	27.5 <sup>d</sup>	65.5 <sup>f</sup>	6.7 <sup>a</sup>	8.6 <sup>a</sup>	9.7 <sup>a</sup>
	Wet	41.2 <sup>a</sup>	85.3 <sup>a</sup>	169.5 <sup>b</sup>	8.1 <sup>a</sup>	9.7 <sup>a</sup>	11.9 <sup>a</sup>
V <sub>3</sub> + SP <sub>2</sub>	Dry	11.0 <sup>d</sup>	26.7 <sup>d</sup>	49.2 <sup>g</sup>	6.8 <sup>a</sup>	8.1 <sup>a</sup>	9.8 <sup>a</sup>
	Wet	43.0 <sup>a</sup>	92.0 <sup>a</sup>	174.6 <sup>a</sup>	8.4 <sup>a</sup>	10.6 <sup>a</sup>	12.5 <sup>a</sup>
V <sub>3</sub> + SP <sub>3</sub>	Dry	9.6 <sup>d</sup>	31.4 <sup>d</sup>	49.7 <sup>g</sup>	6.7 <sup>a</sup>	7.9 <sup>a</sup>	10.1 <sup>a</sup>
	Wet	34.7 <sup>b</sup>	91.8 <sup>a</sup>	123.5 <sup>c</sup>	8.5 <sup>a</sup>	9.1 <sup>a</sup>	12.4 <sup>a</sup>
V <sub>4</sub> + SP <sub>1</sub>	Dry	16.4 <sup>d</sup>	24.1 <sup>d</sup>	65.0 <sup>f</sup>	6.8 <sup>a</sup>	8.7 <sup>a</sup>	9.8 <sup>a</sup>
	Wet	45.0 <sup>a</sup>	83.0 <sup>b</sup>	164.6 <sup>b</sup>	8.9 <sup>a</sup>	10.9 <sup>a</sup>	12.2 <sup>a</sup>
V <sub>4</sub> + SP <sub>2</sub>	Dry	13.7 <sup>cd</sup>	20.7 <sup>d</sup>	70.0 <sup>f</sup>	5.5 <sup>a</sup>	7.0 <sup>a</sup>	8.0 <sup>a</sup>
	Wet	47.2 <sup>a</sup>	90.4 <sup>a</sup>	186.1 <sup>a</sup>	7.7 <sup>a</sup>	10.7 <sup>a</sup>	12.1 <sup>a</sup>
V <sub>4</sub> + SP <sub>3</sub>	Dry	12.8 <sup>cd</sup>	21.5 <sup>d</sup>	85.0 <sup>e</sup>	5.9 <sup>a</sup>	7.9 <sup>a</sup>	9.7 <sup>a</sup>
	Wet	43.3 <sup>a</sup>	65.5 <sup>c</sup>	160.9 <sup>b</sup>	7.9 <sup>a</sup>	9.3 <sup>a</sup>	10.8 <sup>a</sup>

\*Means that do not share a letter are significantly different at 5% probability level

**KEY**

V - varieties, SP - spacing, V<sub>1</sub> - Bendel white, V<sub>2</sub> - OBA 6, V<sub>3</sub> - OBA 98, V<sub>4</sub> - PROVIT A, SP<sub>1</sub> - 60cm × 15cm, SP<sub>2</sub> - 60cm × 30cm, SP<sub>3</sub> - 60cm × 45cm, WAP - Weeks after planting.

**Table 6: Effect of season and spacing on leaf area, stem girth and insect infestation of four studied maize varieties**

Treatment	Season	Leaf area			Stem girth	Insect infestation
		4WAP	6WAP	8WAP		
V <sub>1</sub> + SP <sub>1</sub>	Dry	34.7 <sup>g</sup>	219.0 <sup>de</sup>	318.7 <sup>bc</sup>	7.4 <sup>a</sup>	5.0 <sup>b</sup>
	Wet	116.7 <sup>cd</sup>	323.1 <sup>c</sup>	420.7 <sup>a</sup>	6.7 <sup>a</sup>	1.7 <sup>c</sup>
V <sub>1</sub> + SP <sub>2</sub>	Dry	29.7 <sup>g</sup>	146.7 <sup>e</sup>	319.0 <sup>b</sup>	5.5 <sup>a</sup>	8.0 <sup>a</sup>
	Wet	188.3 <sup>b</sup>	400.8 <sup>b</sup>	479.8 <sup>a</sup>	9.6 <sup>a</sup>	2.3 <sup>c</sup>
V <sub>1</sub> + SP <sub>3</sub>	Dry	26.7 <sup>g</sup>	108.0 <sup>f</sup>	231.3 <sup>c</sup>	5.7 <sup>a</sup>	5.3 <sup>bc</sup>
	Wet	88.5 <sup>e</sup>	339.1 <sup>c</sup>	439.8 <sup>a</sup>	7.9 <sup>a</sup>	3.0 <sup>c</sup>
V <sub>2</sub> + SP <sub>1</sub>	Dry	59.7 <sup>f</sup>	221.7 <sup>d</sup>	321.3 <sup>b</sup>	5.5 <sup>a</sup>	3.3 <sup>c</sup>
	Wet	182.0 <sup>b</sup>	396.6 <sup>b</sup>	383.0 <sup>b</sup>	5.6 <sup>a</sup>	2.0 <sup>c</sup>
V <sub>2</sub> + SP <sub>2</sub>	Dry	91.7 <sup>e</sup>	273.3 <sup>cd</sup>	382.3 <sup>b</sup>	5.7 <sup>a</sup>	5.3 <sup>bc</sup>
	Wet	133.3 <sup>c</sup>	369.6 <sup>b</sup>	458.2 <sup>a</sup>	7.3 <sup>a</sup>	1.7 <sup>c</sup>

V <sub>2</sub> + SP <sub>3</sub>	Dry	55.0 <sup>f</sup>	181.0 <sup>de</sup>	309.3 <sup>bc</sup>	5.3 <sup>a</sup>	2.3 <sup>c</sup>
	Wet	145.3 <sup>c</sup>	326.1 <sup>c</sup>	458.8 <sup>a</sup>	7.1 <sup>a</sup>	2.0 <sup>c</sup>
V <sub>3</sub> + SP <sub>1</sub>	Dry	75.2 <sup>e</sup>	241.7 <sup>d</sup>	314.3 <sup>b</sup>	5.9 <sup>a</sup>	4.7 <sup>bc</sup>
	Wet	143.4 <sup>c</sup>	403.0 <sup>b</sup>	399.2 <sup>ab</sup>	6.0 <sup>a</sup>	1.3 <sup>c</sup>
V <sub>3</sub> + SP <sub>2</sub>	Dry	53.0 <sup>f</sup>	251.7 <sup>d</sup>	320.0 <sup>b</sup>	5.9 <sup>a</sup>	7.0 <sup>ab</sup>
	Wet	188.8 <sup>b</sup>	409.6 <sup>b</sup>	465.8 <sup>a</sup>	7.4 <sup>a</sup>	2.7 <sup>c</sup>
V <sub>3</sub> + SP <sub>3</sub>	Dry	52.0 <sup>f</sup>	518.0 <sup>a</sup>	388.7 <sup>ab</sup>	6.9 <sup>a</sup>	3.7 <sup>c</sup>
	Wet	119.7 <sup>cd</sup>	421.3 <sup>b</sup>	467.5 <sup>a</sup>	7.4 <sup>a</sup>	1.0 <sup>c</sup>
V <sub>4</sub> + SP <sub>1</sub>	Dry	103.3 <sup>d</sup>	205.3 <sup>de</sup>	318.3 <sup>b</sup>	6.1 <sup>a</sup>	5.3 <sup>b</sup>
	Wet	184.1 <sup>b</sup>	405.0 <sup>b</sup>	422.7 <sup>a</sup>	6.2 <sup>a</sup>	2.0 <sup>c</sup>
V <sub>4</sub> + SP <sub>2</sub>	Dry	81.7 <sup>e</sup>	178.0 <sup>de</sup>	268.3 <sup>c</sup>	5.1 <sup>a</sup>	6.0 <sup>b</sup>
	Wet	221.0 <sup>a</sup>	383.8 <sup>b</sup>	477.0 <sup>a</sup>	7.1 <sup>a</sup>	2.0 <sup>c</sup>
V <sub>4</sub> + SP <sub>3</sub>	Dry	91.3 <sup>e</sup>	197.0 <sup>de</sup>	280.7 <sup>c</sup>	6.3 <sup>a</sup>	5.0 <sup>bc</sup>
	Wet	205.5 <sup>a</sup>	312.5 <sup>c</sup>	417.2 <sup>a</sup>	6.6 <sup>a</sup>	1.7 <sup>c</sup>

\*Means that do not share a letter are significantly different at 5% probability level

### KEY

V - varieties, SP - spacing, V<sub>1</sub> - Bendel white, V<sub>2</sub> - OBA 6, V<sub>3</sub> - OBA 98, V<sub>4</sub> - PROVIT A, SP<sub>1</sub> - 60cm × 15cm, SP<sub>2</sub> - 60cm × 30cm, SP<sub>3</sub> - 60cm × 45cm, WAP - Weeks after planting.

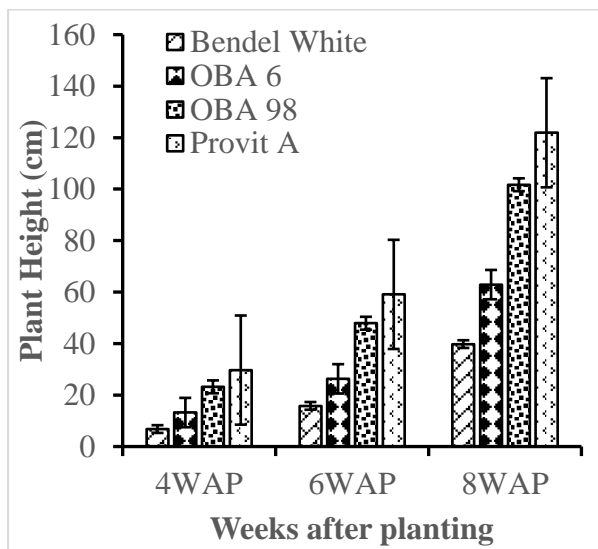


Fig. 1: Varietal response on plant height

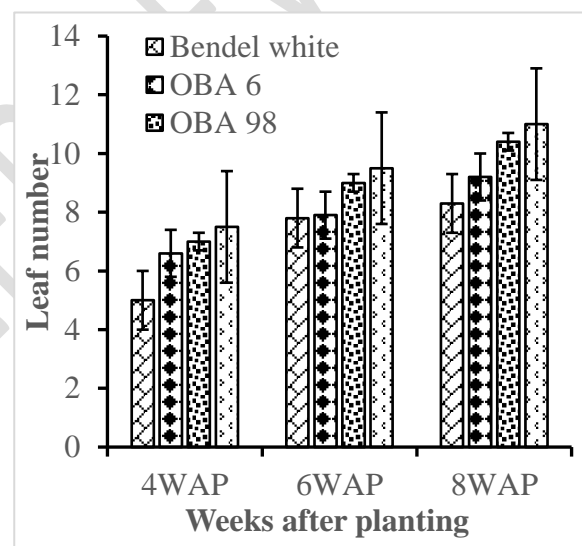


Fig. 2: Varietal response on leaf number

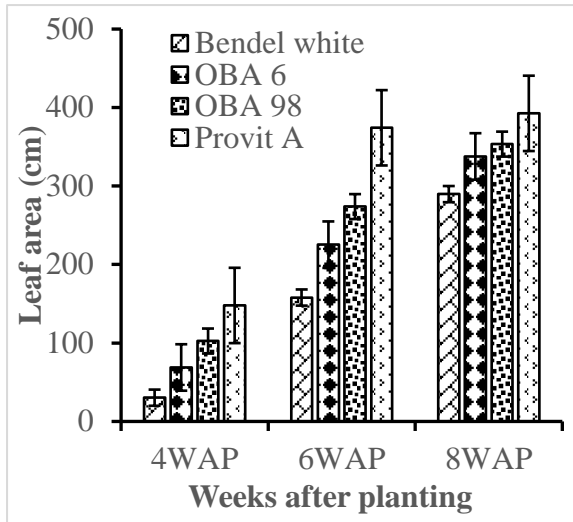


Fig. 3: Varietal response on leaf area

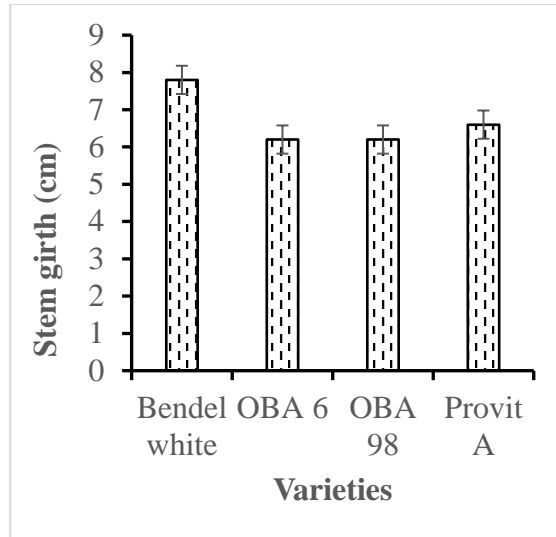


Fig. 4: Varietal response on stem girth

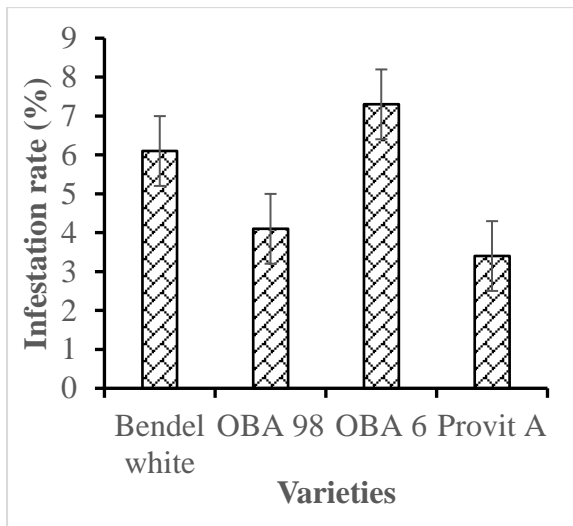


Fig. 5: Varietal response on insect infestation

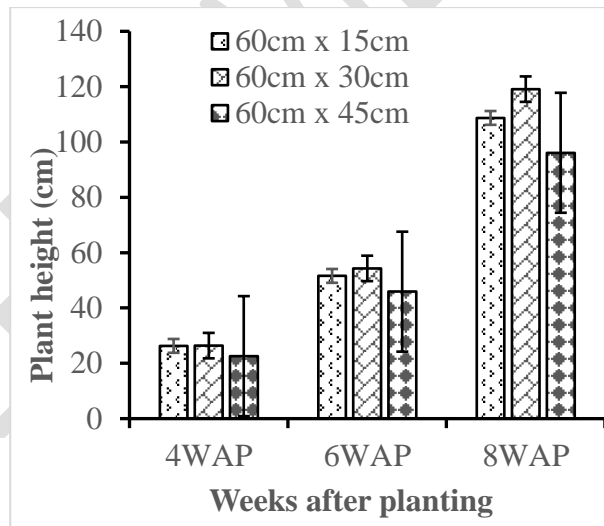


Fig. 6: Effect of spacing on plant height

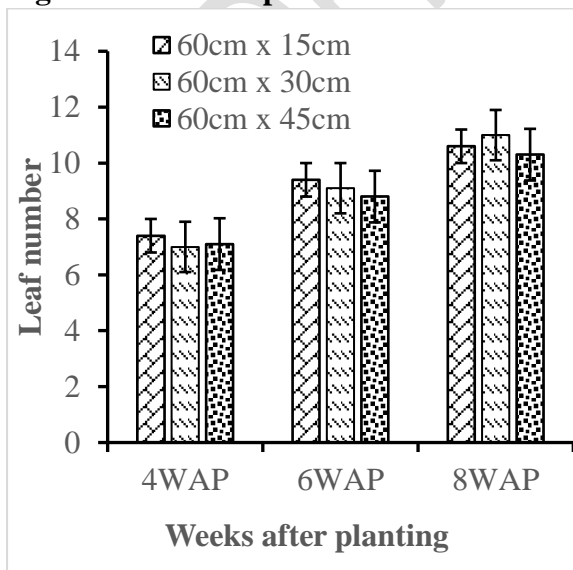


Fig. 7: Effect of spacing on leaf number

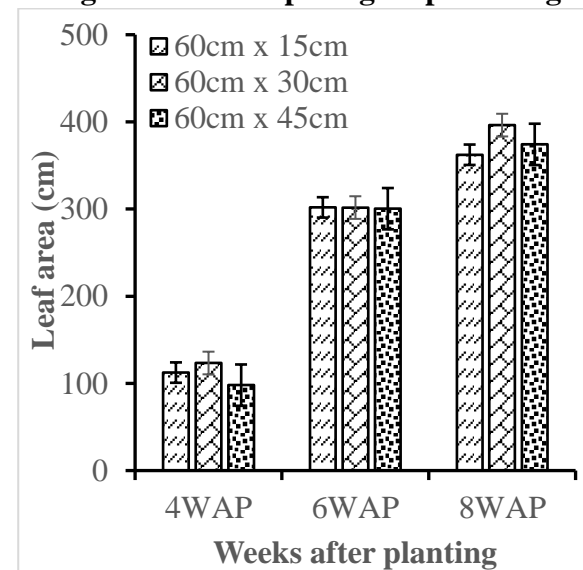
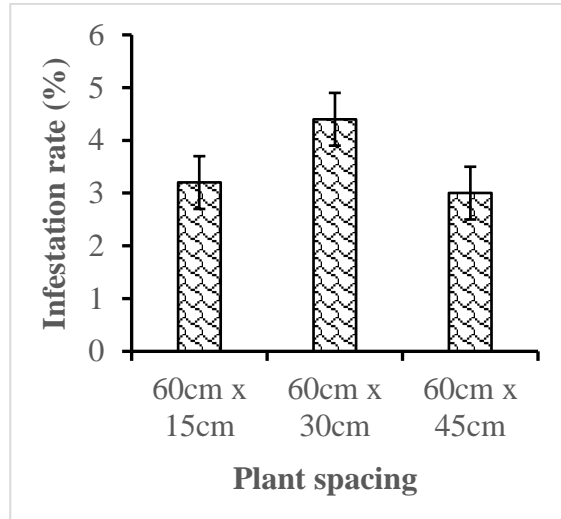
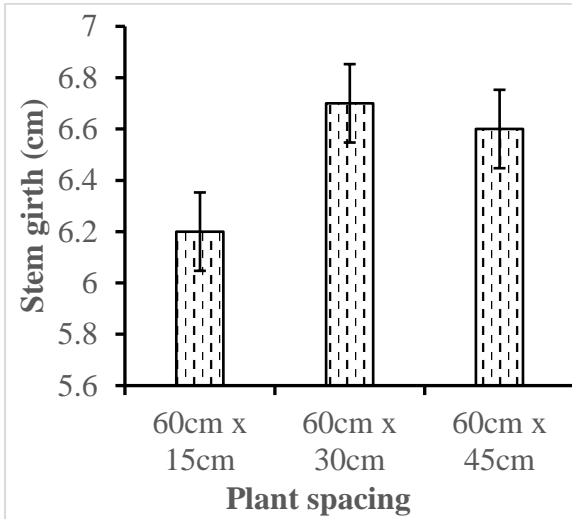
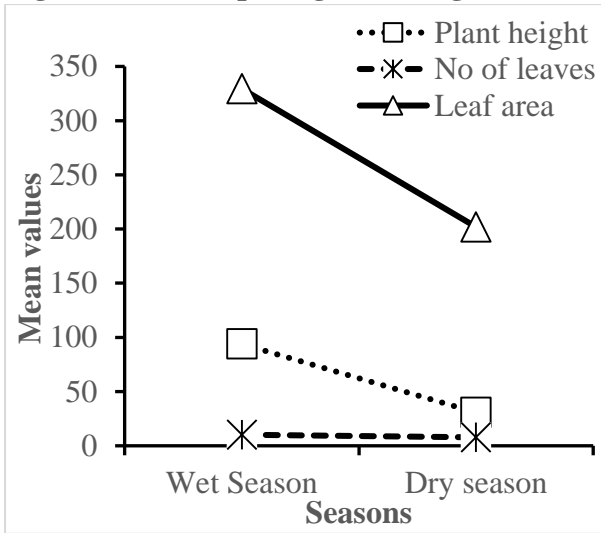


Fig. 8: Effect of spacing on leaf area

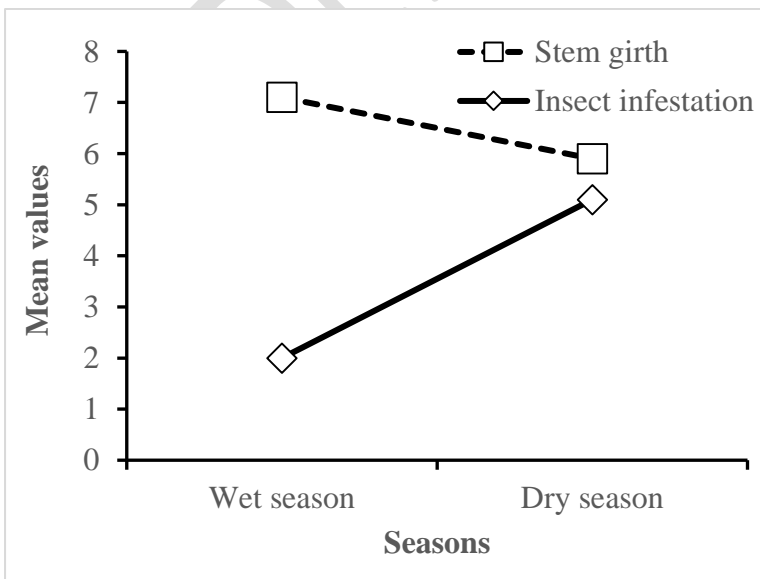


**Fig. 9: Effect of spacing on stem girth**

**Fig. 10: Effect of spacing on insect infestation**



**Fig. 11: Seasonal effect on plant height, number of leaves and leaf area**



**Fig. 12: Seasonal effect on stem girth and insect infestation**

#### 4.0 DISCUSSION

Result on plant densities revealed that 60cm x 30cm spacing encouraged high growth characters (plant height, leaf area and stem girth) while the lowest was in 60cm x 45cm. This result is in line with the reports of Alam *et al.* (2020) that observed high plant height, stem diameter and leaf length compared to other spacings used in the experiment. This statement is in contrast with the observations of Zamir *et al.* (2011) and Khubna *et al.* (2021) that observed poor growth qualities associated with 60cm x 30cm but noted high growth characters in spacing 60cm x 15cm and 60cm x 60cm respectively. Reports from this study is similar to the findings of Widdicombe and Thelen (2002) that ascribed the rapid growth rates and early canopy formation of narrow row spaced crops to search for space, sunlight and nutrients. 60cm x 15cm had high leaf number in this study and this is corroborated by the reports of Ramhari *et al.* (2020) that noticed good growth traits in 60cm x 15cm of Arum-2 maize variety. Zamir *et al.* (2011) further reported good plant height and straw yield of maize planted with spacing of 60cm x 15cm. Konuskan (2000) report on stem diameter opposed the findings of this study. The researcher stated that stem diameter was lower in higher plant spacings as a consequence of interplant competitions (Konushan, 2000).

Varietal influence in this research revealed that Provit A variety had high plant height, leaf area and leaf number compared to other varieties studied. This variation in the growth traits of the studied varieties is attributed to the difference in genetic makeup of the individual varieties (Ibrahim *et al.*, 2000; Akpan *et al.*, 2021). In this study, it was observed that hybrid varieties (OBA super 6, OBA super 98, Provit A) exhibited good growth qualities like plant height, number of leaves and leaf area than the local variety (Bendel white) but the local variety had high stem girth than hybrid maize varieties. This observation of hybrid varieties was in agreement with the reports of Bashyal *et al.* (2020) that reported high plant height, leaf area index and leaf number in hybrid maize varieties than local maize variety. The superiority of Bendel local maize variety in stem girth is due to genomic buildup of the variety.

It is worthy to note that in the interaction between variety and spacing, Provit A variety with spacing of 60cm x 30cm had the highest plant height; Provit A variety with spacing of 60cm x 45cm had high number of leaves and leaf area while Bendel white variety with spacing of 60cm x 30cm had high stem girth respectively. This variation in the characteristics of the maize variety to different densities in the study is dependent on the plant genotype, climatic factor and environmental factor (Gozubenii *et al.*, 2001). Result on the seasonal effect revealed that wet season favoured optimum growth and yield of the maize varieties studied than dry season. This low yield output experienced in dry season confirms the statement of Prasad *et al.* (2014b) that high temperature negatively affects vegetative development and fertilization likewise water stress during crucial growth stages adversely impact yield and quality.

This research study showed that Bendel white variety spaced 60cm x 30cm was more prone to insect invasion and the lowest insect attack was OBA 6 spaced with 60cm x 45cm. This result corroborates the statement of Degri and Randy (2019). The researchers suggested that the insect feeding activity is encouraged in closely spaced crops. Varietal response to insect infestation in this research study ranged from OBA 6 > Bendel white > OBA 98 > Provit A. This varietal variation may be due to genetic makeup and physiology of the distinct varieties as different varieties exhibit varying levels of resistance or tolerance to insect pest (Youdeowei,

2004; Akpan *et al.*, 2021). Seasonal response revealed that dry season highly favoured insect invasion and this result is in agreement with findings of Caniço *et al.* (2020). Caniço *et al.* (2020) reported increase in infestation, damages and population density of insect in dry season than rainy season. They further suggested that rainy season alters insect pest development and reproduction thereby resulting to migration for their survival thus reducing their population in the field.

## 5.0 CONCLUSION

This study showed that plant spacing and variety positively influenced most of the growth parameters of maize. The result also indicated that variety Provit A was the more suitable of the four maize varieties sampled, and plant spacing 60cm x 30cm was ideal to attain optimum growth.

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