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Comparative Assessment of the Effect of Three Plant Spacing on the Performance of Maize (*Zea mays* L.) Varieties in the Humid Tropics of Port Harcourt, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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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)

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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 variety 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. 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 [1,2]. FAO [3] 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 [4]. 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 [4,5].

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 [6] and survives for only one growing season attaining a height of 2-4m [7]. It is an annual, tall, determinate with narrow opposing leaves alternating along the stem length [2]. 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 [2].

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 [8,9,10,11] (Zeidan *et al.*, 2006) [12]. 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 [13,14,15].

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 [16], 60cm × 60cm [17] and 60cm × 15cm [18,19]. This research is therefore aimed at comparing the growth performance of the varieties as influenced by different intra-row and inter-row spacing.

2. 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℃ to 33℃ 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 $6m^2$ in a replicate.

2.5 Land Preparation / Planting and Establishment

The area was manually cleared and plots of $6m^2$ 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 $6m^2$. 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 of leaves were counted directly from ten (10) 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. [7].

$$LA = 0.75\ LW$$

d) Stem girth

Stem girth was measured from ten randomly selected maize stands with measuring tape at 8 weeks after planting in each plot.

e) Insect Infestation

Infestation of each plot by insects was assessed visually from ten randomly selected maize plants 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 [20].

3. 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_1 + SP_2 + wet had high mean stem girth of 9.6 followed by V_1 + SP_3 + wet (7.9) while the least mean was recorded in V_3 + SP_2 + dry (5.1) respectively. Table 6 also revealed that V_1 + SP_2 + dry was significantly higher (P<0.05) with mean value of 8.0% followed by V_4 + SP_2 + dry (7.0%) whereas the lowest infestation rate was in V_4 + SP_3 + 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
$V_1 + SP_1$	19.8^{b}	42.3^{c}	89.7^{c}	6.3^{a}	9.5^{a}	10.5^{a}
$V_1 + SP_2$	21.2^{b}	47.3^{c}	107.2^{b}	6.5^{a}	9.1^{a}	11.0^{a}
$V_1 + SP_3$	14.8^{b}	34.5^{c}	67.3^{c}	6.3^{a}	7.8^{a}	9.3^{a}
$V_2 + SP_1$	28.7^{a}	54.2^{b}	112.7^{b}	7.9^{a}	9.3^{a}	10.2^{a}
$V_2 + SP_2$	27.1^{ab}	55.0^{b}	129.1^{ab}	7.4^{a}	9.2^{a}	11.6^{a}
$V_2 + SP_3$	25.3^{b}	43.9^{c}	107.6^{b}	7.2^{a}	8.6^{a}	10.4^{a}
$V_3 + SP_1$	26.1^{ab}	53.5^{b}	117.5^{b}	7.9^{a}	9.8^{a}	11.0^{a}
$V_3 + SP_2$	27.0^{ab}	55.5^{b}	111.9^{b}	6.6^{a}	8.8^{a}	10.0^{a}
$V_3 + SP_3$	22.2^{b}	43.5^{c}	86.5^{c}	6.9^{a}	8.6^{a}	10.3^{a}
$V_4 + SP_1$	30.7^{a}	56.4^{a}	114.8^{b}	7.4^{a}	9.1^{a}	10.8^{a}
$V_4 + SP_2$	30.4^{a}	59.3^{a}	128.1^{a}	7.6^{a}	9.3^{a}	11.1^{a}
$V_4 + SP_3$	28.1^{a}	61.6^{a}	122.9^{a}	7.6^{a}	10.2^{a}	11.2^{a}

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

***KEY**: V - varieties, SP - spacing, V_1 – Bendel white, V_2 - OBA 6, V_3 - OBA 98, V_4 - PROVIT A, SP_1 - 60cm × 15cm, SP_2 - 60cm × 30cm, SP_3 - 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		
$V_1 + SP_1$	75.7^{c}	271.1^{c}	369.7^{b}	7.0^{a}	3.3^{bc}
$V_1 + SP_2$	109.0^{b}	273.7^{c}	399.4^{ab}	7.5^{a}	5.2^{a}
$V_1 + SP_3$	57.6^{c}	223.5^{c}	335.6^{b}	6.8^{a}	4.2^{b}
$V_2 + SP_1$	120.8^{b}	309.1^{bc}	352.2^{b}	5.6^{a}	2.7^{c}
$V_2 + SP_2$	112.5^{b}	321.5^{bc}	420.3^{a}	6.5^{a}	3.5^{bc}
$V_2 + SP_3$	100.2^{b}	253.5^{c}	384.1^{b}	6.2^{a}	2.2^{c}
$V_3 + SP_1$	109.3^{b}	305.2^{bc}	370.5^{b}	6.1^{a}	3.7^{bc}
$V_3 + SP_2$	120.9^{b}	280.9^{bc}	372.7^{b}	6.1^{a}	4.0^{b}
$V_3 + SP_3$	85.8^{c}	254.8^{c}	348.9^{b}	6.5^{a}	3.3^{bc}
$V_4 + SP_1$	143.7^{a}	322.3^{b}	356.8^{b}	5.9^{a}	3.0^{bc}
$V_4 + SP_2$	151.3^{a}	330.6^{b}	392.9^{ab}	6.7^{a}	4.8^{b}
$V_4 + SP_3$	148.4^{a}	469.6^{a}	428.1^{a}	7.1^{a}	2.3^{c}

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

KEY: V - varieties, SP - spacing, V_1 – Bendel white, V_2 - OBA 6, V_3 - OBA 98, V_4 - PROVIT A, SP_1 - 60cm × 15cm, SP_2 - 60cm × 30cm, SP_3 - 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^{b}	9.9^{a}	310.8^{a}
	Dry	20.8^{c}	7.0^{a}	159.3^{c}
OBA 6	Wet	95.5^{ab}	10.2^{a}	317.0^{a}
	Dry	34.1^{c}	7.9^{a}	210.6^{bc}
OBA 98	Wet	100.3^{a}	10.4^{a}	336.8^{a}
	Dry	29.1^{c}	7.7^{a}	180.9^{c}
Provit A	Wet	101.8^{a}	10.4^{a}	353.0^{a}
	Dry	38.7^{c}	8.4^{a}	256.7^{b}

**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^{a}	2.3^{c}
	Dry	6.2^{b}	6.1^{a}
OBA 6	Wet	6.7^{b}	1.9^{c}
	Dry	5.5^{b}	3.7^{a}
OBA 98	Wet	6.7^{b}	2.0^{c}
	Dry	5.8^{b}	5.4^{a}
Provit A	Wet	6.9^{b}	1.7^{c}
	Dry	6.2^{b}	5.1^{b}

**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
$V_1 + SP_1$	Dry	7.3^{d}	21.0^{d}	52.2^{fg}	5.2^{a}	9.8^{a}	9.6^{a}
	Wet	32.3^{b}	63.7^{c}	127.2^{c}	7.4^{a}	9.2^{a}	11.5^{a}
$V_1 + SP_2$	Dry	6.9^{d}	14.7^{d}	42.5^{g}	4.7^{a}	6.9^{a}	7.9^{a}
	Wet	35.5^{b}	79.8^{b}	17.0^{h}	8.3^{a}	11.4^{a}	14.1^{a}
$V_1 + SP_3$	Dry	6.2^{d}	11.6^{d}	24.7^{h}	5.2^{a}	6.8^{a}	7.4^{a}
	Wet	23.3^{c}	57.5^{c}	109.8^{d}	7.3^{a}	8.8^{a}	11.3^{a}
$V_2 + SP_1$	Dry	12.6^{d}	25.8^{d}	60.4^{f}	6.8^{a}	7.8^{a}	9.1^{a}
	Wet	44.8^{a}	82.7^{a}	165.1^{b}	8.9^{a}	10.7^{a}	11.3^{a}
$V_2 + SP_2$	Dry	15.5^{c}	32.4^{d}	80.1^{e}	6.9^{a}	8.3^{a}	10.2^{a}
	Wet	38.7^{ab}	77.7^{b}	178.2^{a}	7.9^{a}	10.1^{a}	13.1^{a}
$V_2 + SP_3$	Dry	11.5^{d}	20.9^{d}	48.3^{g}	6.2^{a}	7.6 ^{a}	8.3^{a}
	Wet	39.1^{a}	66.8^{c}	166.8^{b}	8.1^{a}	9.5^{a}	12.5^{a}
$V_3 + SP_1$	Dry	11.0^{d}	27.5^{d}	65.5^{f}	6.7^{a}	8.6^{a}	9.7^{a}
	Wet	41.2^{a}	85.3^{a}	169.5^{b}	8.1^{a}	9.7^{a}	11.9^{a}
$V_3 + SP_2$	Dry	11.0^{d}	26.7^{d}	49.2^{g}	6.8^{a}	8.1^{a}	9.8^{a}
	Wet	43.0^{a}	92.0^{a}	174.6^{a}	8.4^{a}	10.6^{a}	12.5^{a}
$V_3 + SP_3$	Dry	9.6^{d}	31.4^{d}	49.7^{g}	6.7^{a}	7.9^{a}	10.1^{a}
	Wet	34.7^{b}	91.8^{a}	123.5^{c}	8.5^{a}	9.1^{a}	12.4^{a}
$V_4 + SP_1$	Dry	16.4^{d}	24.1^{d}	65.0^{f}	6.8^{a}	8.7^{a}	9.8^{a}
	Wet	45.0^{a}	83.0^{b}	164.6^{b}	8.9^{a}	10.9^{a}	12.2^{a}
$V_4 + SP_2$	Dry	13.7^{cd}	20.7^{d}	70.0^{f}	5.5^{a}	7.0^{a}	8.0^{a}
	Wet	47.2^{a}	90.4^{a}	186.1^{a}	7.7^{a}	10.7^{a}	12.1^{a}
$V_4 + SP_3$	Dry	12.8^{cd}	21.5^{d}	85.0^{e}	5.9^{a}	7.9^{a}	9.7^{a}
	Wet	43.3^{a}	65.5^{c}	160.9^{b}	7.9^{a}	9.3^{a}	10.8^{a}

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

KEY: V - varieties, SP - spacing, V_1 – Bendel white, V_2 - OBA 6, V_3 - OBA 98, V_4 - PROVIT A, SP_1 - 60cm × 15cm, SP_2 - 60cm × 30cm, SP_3 - 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		
$V_1 + SP_1$	Dry	34.7^{g}	219.0^{de}	318.7^{bc}	7.4^{a}	5.0^{b}
	Wet	116.7^{cd}	323.1^{c}	420.7^{a}	6.7^{a}	1.7^{c}
$V_1 + SP_2$	Dry	29.7^{g}	146.7^{e}	319.0^{b}	5.5^{a}	8.0^{a}
	Wet	188.3^{b}	400.8^{b}	479.8^{a}	9.6^{a}	2.3^{c}
$V_1 + SP_3$	Dry	26.7^{g}	108.0^{f}	231.3^{c}	5.7^{a}	5.3^{bc}
	Wet	88.5^{e}	339.1^{c}	439.8^{a}	7.9^{a}	3.0^{c}
$V_2 + SP_1$	Dry	59.7^{f}	221.7^{d}	321.3^{b}	5.5^{a}	3.3^{c}
	Wet	182.0^{b}	396.6^{b}	383.0^{b}	5.6^{a}	2.0^{c}
$V_2 + SP_2$	Dry	91.7^{e}	273.3^{cd}	382.3^{b}	5.7^{a}	5.3^{bc}
	Wet	133.3^{c}	369.6^{b}	458.2^{a}	7.3^{a}	1.7^{c}
$V_2 + SP_3$	Dry	55.0^{f}	181.0^{de}	309.3^{bc}	5.3^{a}	2.3^{c}
	Wet	145.3^{c}	326.1^{c}	458.8^{a}	7.1^{a}	2.0^{c}
$V_3 + SP_1$	Dry	75.2^{e}	241.7^{d}	314.3^{b}	5.9^{a}	4.7^{bc}
	Wet	143.4^{c}	403.0^{b}	399.2^{ab}	6.0^{a}	1.3^{c}
$V_3 + SP_2$	Dry	53.0^{f}	251.7^{d}	320.0^{b}	5.9^{a}	7.0^{ab}
	Wet	188.8^{b}	409.6^{b}	465.8^{a}	7.4^{a}	2.7^{c}
$V_3 + SP_3$	Dry	52.0^{f}	518.0^{a}	388.7^{ab}	6.9^{a}	3.7^{c}
	Wet	119.7^{cd}	421.3^{b}	467.5^{a}	7.4^{a}	1.0^{c}
$V_4 + SP_1$	Dry	103.3^{d}	205.3^{de}	318.3^{b}	6.1^{a}	5.3^{b}
	Wet	184.1^{b}	405.0^{b}	422.7^{a}	6.2^{a}	2.0^{c}
$V_4 + SP_2$	Dry	81.7^{e}	178.0^{de}	268.3^{c}	5.1^{a}	6.0^{b}
	Wet	221.0^{a}	383.8^{b}	477.0^{a}	7.1^{a}	2.0^{c}
$V_4 + SP_3$	Dry	91.3^{e}	197.0^{de}	280.7^{c}	6.3^{a}	5.0^{bc}
	Wet	205.5^{a}	312.5^{c}	417.2^{a}	6.6^{a}	1.7^{c}

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

KEY: V - varieties, SP - spacing, V_1 – Bendel white, V_2 - OBA 6, V_3 - OBA 98, V_4 - PROVIT A, SP_1 - 60cm × 15cm, SP_2 - 60cm × 30cm, SP_3 - 60cm × 45cm, WAP – Weeks after planting

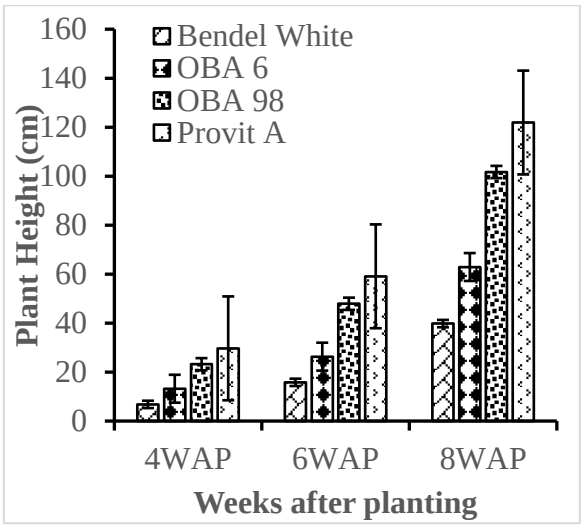

Fig. 1. Varietal response on plant height

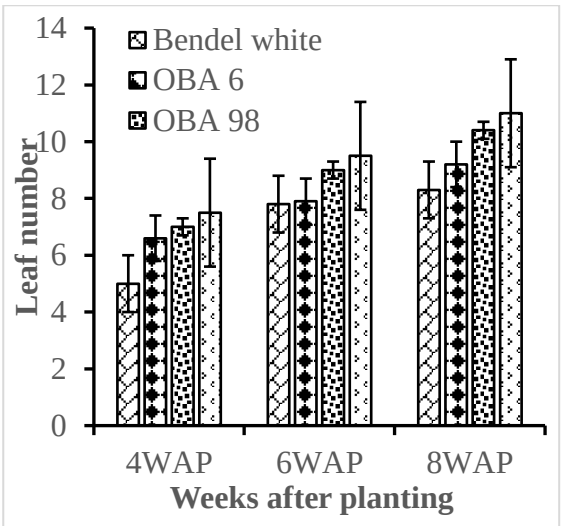

Fig. 2. Varietal response on leaf number

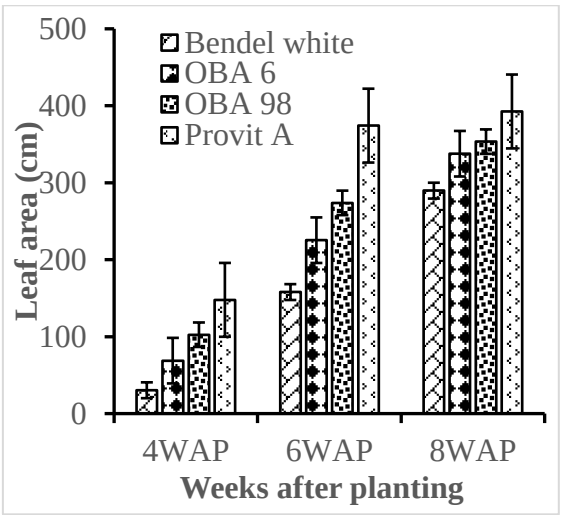

Fig. 3. Varietal response on leaf area

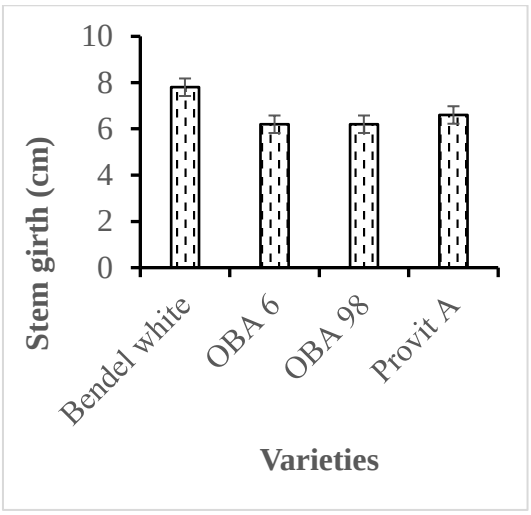

Fig. 4. Varietal response on stem girth

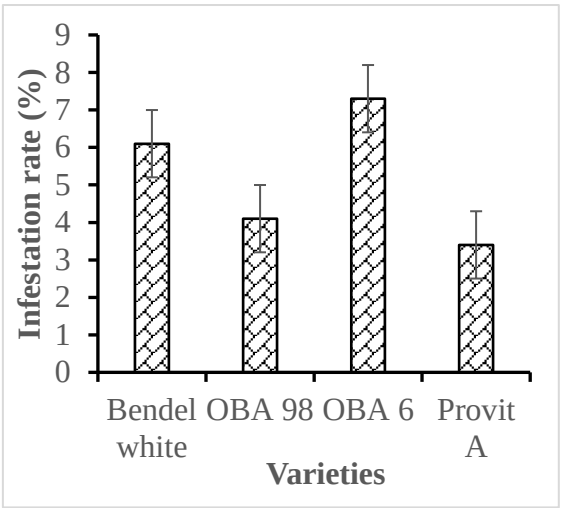

Fig. 5. Varietal response on insect infestation

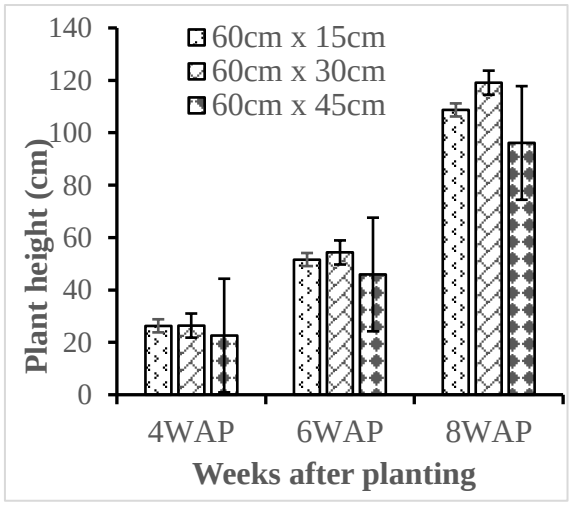

Fig. 6. Effect of spacing on plant height

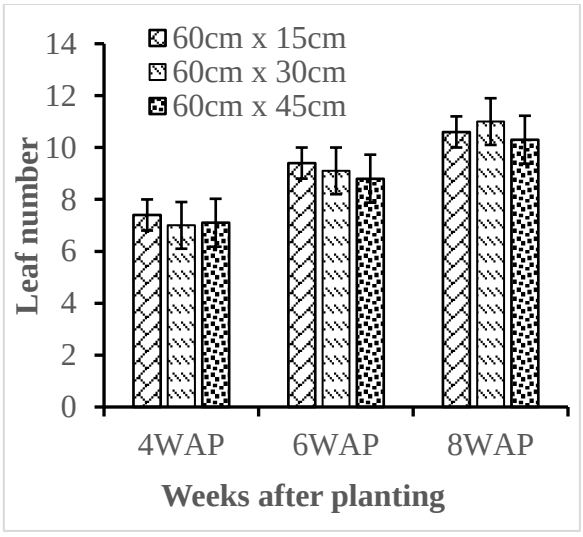

Fig. 7. Effect of spacing on leaf number

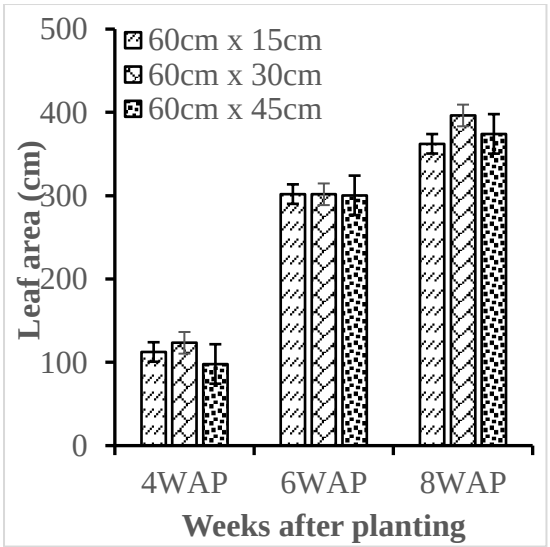

Fig. 8. Effect of spacing on leaf area

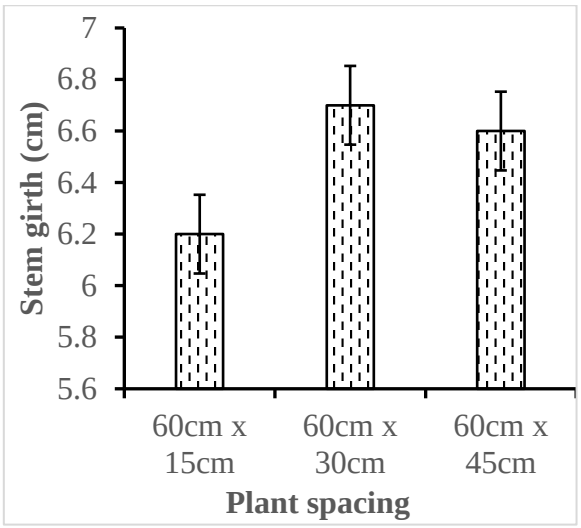

Fig. 9. Effect of spacing on stem girth

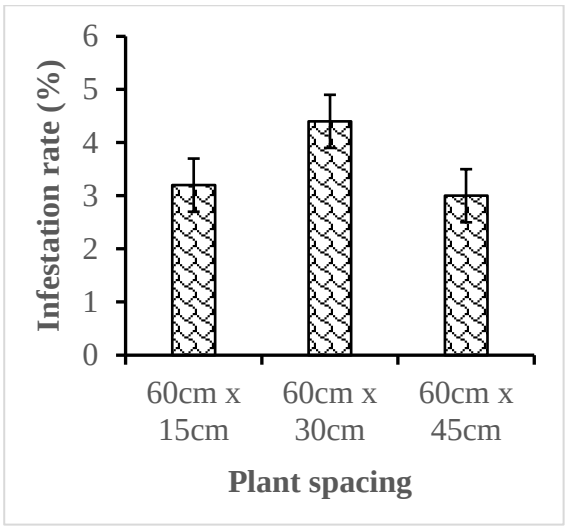

Fig. 10. Effect of spacing on insect infestation

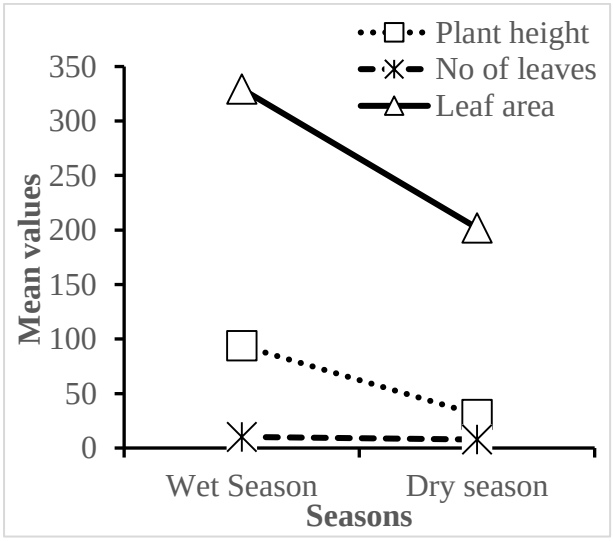

Fig. 11. Seasonal effect on plant height, number of leaves and leaf area

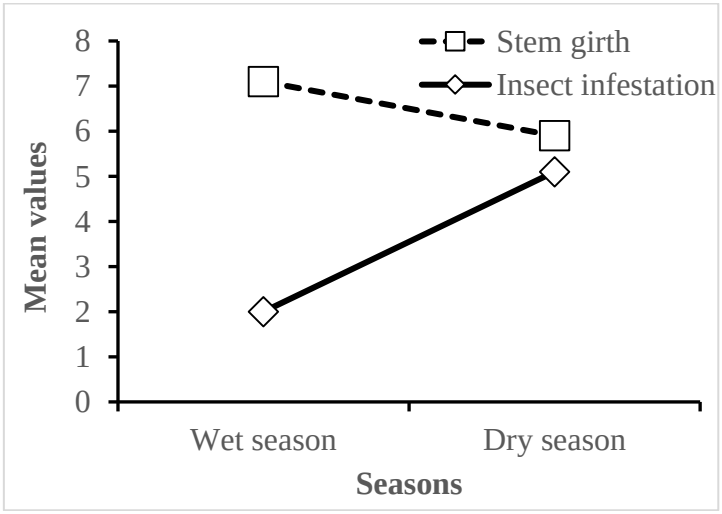

Fig. 12. Seasonal effect on stem girth and insect infestation

4. 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. [21] 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. [18] and Khubna et al. [17] that observed poor growth qualities associated with 60cm × 30cm but noted high growth characters in spacing 60cm × 15cm and 60cm × 60cm respectively. Reports from this study is similar to the findings of Widdicombe and Thelen [22] that ascribed the rapid growth rates and early canopy formation of narrow row spaced crops to search for space, sunlight and nutrients. 60cm × 15cm had high leaf number in this study and this is corroborated by the reports of Ramhari et al. [19] that noticed good growth traits in 60cm × 15cm of Arum-2 maize variety. Zamir et al. [18] further reported good plant height and straw yield of maize planted with spacing of 60cm × 15cm. Konuskan [23] 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 [23].

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 [24,7]. 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. [25] 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 × 30cm had the highest plant height; Provit A variety with spacing of 60cm × 45cm had high number of leaves and leaf area while Bendel white variety with spacing of 60cm × 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 [26]. 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. [27] 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 × 30cm was more prone to insect invasion and the lowest insect attack was OBA 6 spaced with 60cm × 45cm. This result corroborates the statement of Degri and Randy [28]. 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 [29,7]. Seasonal response revealed that dry season highly favoured insect invasion and this result is in agreement with findings of Caniço et al. [30]. Caniço et al. [30] 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. 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 most suitable of the four maize varieties sampled, and plant spacing 60cm x 30cm was ideal to attain optimum growth. Wet season promoted growth performance while dry season increased insect infestation rate. Therefore, Provit A variety and spacing 60cm x 30cm are recommended for cultivation by farmers in Humid tropics of Port Harcourt.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dhaka BL, Meena BS, Suwalka RL. Popularization of improved maize production technology through frontline demonstrations in south-eastern Rajasthan. Journal of Agricultural Sciences. 2010;1(1):39-42.
2. Kumar S, Shivani M, Meena K, Singh SS. Production potential and plant water status in transplanted maize as influenced by method of seed raining and age of seedling under irrigated midlands of Eastern India. International Journal of Agricultural Stat. 2012;8(2):697-704.
3. FAO. Fertilizer and the future. IFA/FAO Agriculture Conference on Global food security and the role of Sustainability Fertilization. Rome, Italy. 16th-20th March. 2002;2003:1-2.
4. FAOSTAT. Food and Agricultural Organization of the United Nations (FAO). FAO Statistical Data base; 2014. Available:http://faostat.fao.org
5. Food and Agriculture Organisation, FAO. World food and agriculture-Statistical yearbook; 2021. ISBN 978-92-5-134332-6
6. Sprague GF, Dudley JW. Corn and Corn Improvement ed. p. 653 – 682. Madison, Wisconsin, USA; 1988.
7. Akpan EU, Afegheze EC, Young DG. Effect of intra row spacing on the growth and yield of maize (*Zea mays* L.) varieties in southern guinea savanna of Nigeria. International Journal of Environment, Agriculture and Biotechnology. 2021;6(5):97-106.
8. Fayenisin O. Search for Improved maize varieties for farmers in Nigeria. 3rd National Workshop of Maize Centre. NASPP, Ibadan December, 6th - 10th 1976; 1993.
9. Kim SK. Achievement, challenges and future direction of hybrid maize research and product in B. Badu Apraku, Akoroda M.O., Oedraw M. and Quin F.M(eds). Proceedings of Required Maize Workshop May 9 - June 2, 1995. IITA Cotonou, Benin Republic; 1997.
10. Assefa T. Survey of maize diseases in western and north- western Ethiopia. In the sixth Eastern and Southern Africa Regional Maize Conference, CIMMYT. Addis Ababa, Ethiopia. 1998;121-124.
11. DIPA. Handbook of Agriculture: facts and figures for farmers, students and all interested in farming. Directorate of Information and Publications of Agriculture. Indian Council of Agricultural Research, New Delhi. 2006;435.
12. Enujeke EC. Effects of variety and spacing on growth characters of hybrid maize. Asian J. Agric. Rural Dev. 2013a;3(5):296-310.
13. Buriro M, Bhutto TA, Gandahi AW, Kumbhar IA, Shar MU, Effect of sowing dates on growth, yield and grain quality of hybrid maize. J. Basic Appl. Sci. 2015;11:553-558.
14. Kamara AY, Kamai N, Omoigui LO, Togola A, Onyibe JE. Guide to Maize Production in Northern Nigeria: Ibadan, Nigeria. 2020;18.
15. Rabbani B, Ali Jawed Safdary AJ. Effect of sowing date and plant density on yield and yield components of three maize (*Zea mays* L.) genotypes in Takhar climatic conditions of Afghanistan. Central Asian Journal of Plant Science Innovation. 2021;1(2):109–120.
16. Ukonze JA, Akor VO, Ndubuaku UM. Comparative analysis of three different spacing on the performance and yield of late maize cultivation in Etche local government area of Rivers State, Nigeria. African Journal of Agricultural Research. 2016;11(13):1187-1193.
17. Khubna M, Supriyono E, S Nyoto S, M T S Budiastuti MTS. The growth and yield of hybrid corn on different plant spacing. IOP Conf. Series: Earth and Environmental Science. 2021;637:1-7.
18. Zamir MSI, Ahmad AH, Javeed HMR, Latif T. Growth and yield behaviour of two maize hybrids (Zea mays L.) towards different plant spacing. Cercetări Agronomice în Moldova. 2011;14(2):33-40.
19. Ramhari G, Chudamani P, Nischal S, Rajan D, Tej NB. Effect of Spacing and Nitrogen Level on Growth and Yield of Maize (Zea mays L.) in Mid hill of Nepal. Malaysian Journal of Halal Research Journal (MJHR). 2020;3(2):50-55.

20. Minitab 17 statistical software. computer software state college, P.A: Minitab, Inc; 2019.
Available:(www.minitab.com)
21. Alam MJ, Uddin MA, Nahar MK, Ali MY, Ahmed KS. Enhancement of maize productivity through using improved techniques of spacing. Journal of Experimental Bioscience. 2020;11(2):27-34.
22. Widdicombe WD, Thelen KD. Row width and plant density effects on corn grain production in the Northern Corn Belt. Agronomy Journal. 2002;94:1020 – 1024.
23. Konuskan O. Effects of plant density on yield and yield related characters of some maize hybrids grown in Hatay conditions as second crop. M.Sc. Thesis, Science Institute. M.K.U. 2000;71.
24. Ibrahim K, Amans A, Abubakar IU. Growth indices and yield of Tomato (*Lycopesicon esculentum* karest) varieties as influenced by crop spacing at Samaru. Proceedings of the 18th HORTSON Conference Proceedings. 2000 ;(1):40-47.
25. Bashyal S, Poudel PB, Magar JB, Dhakal L, Chad S, Khadka B, Bohara SL. Effect of Nutrient Management on Two Varieties (Hybrid and Local) of Maize in Western Inner Terai of Nepal. International Journal of Applied Sciences and Biotechnology. 2020;8(2):191-198.
26. Gozubenii H, Ulger AC, Sener O. The effect of different nitrogen doses on grain yield and yield-related characters of some maize genotypes grown as second crop. J. Agric. Fac. C.U. 2001;16:39-48.
27. Prasad PVV, Reddy VR, Rao AS. Effect of seasonal variations on maize yield. International Journal of Agricultural Science and Research. 2014b;4(2):21-28.
28. Degri MM, Randy S. Effect of variety and spacing on insect pest infestations and growth of Amaranthus (*Amaranthus spp*) in Alau Dam, Maiduguri, Nigeria. African Journal of Agronomy. 2019;7(1):1-5.
29. Youdeowei A. Integrated pest management practices for the production of vegetables. Ministry of Food and Agriculture, Ghana. 2004;49.
30. Caniço A, Mexia A, Santos L. Seasonal dynamics of the Alien invasive insect species *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) in Manica Province, Central Mozambique. Insects. 2020;11(8):512-522.

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