**Original Paper**

# Growth and yield of maize (*Zea mays* L.) as influenced by cropping pattern and weed control treatments in the forest – savanna agro-ecological zone of southwest Nigeria

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Article Details: Received: 2022-08-30 | Accepted: 2022-11-22 | Available online: 2023-06-30

https://doi.org/10.15414/afz.2023.26.02.155-162



Field trials were conducted in the early cropping seasons of 2014, 2015 and 2016 at Federal University of Agriculture, Abeokuta (7° 20′ N, 3° 23′ E) Nigeria to evaluate intercropped cucumber and jackbean as supplements to pre-emergence herbicides on growth and yield of maize. The treatments were arranged in a split – plot arrangement fitted into Randomized Complete Block Design (RCBD) with three replications. The six main plot treatments consisted of maize at 100 × 37.5 cm intercropped with cucumber, maize at 100 × 37.5 cm intercropped with jackbean, maize at 75 × 50 cm intercropped with cucumber, maize at 75 × 50 cm intercropped with jackbean, sole maize at 100 × 37.5 cm, sole maize at 75 × 50 cm, completed the treatments as controls. Eight treatments were assigned to the sub – plot. Data collected were subjected to Analysis of Variance while significant means were separated using Duncan`s Multiple Range Test ($p$ <0.05). Sole maize at 75 × 50 cm and the intercrop with jackbean consistently produced significantly higher ($p$ <0.05) shoot dry matter, compared to other cropping patterns while maize intercropped with cucumber depressed the aforementioned parameter. Propaben at 1.6 kg a.i·ha$^{-1}$ followed by (fb) supplementary hoe weeding (SHW) resulted in higher stand count, vigour score, shoot dry matter and maize cob yield relative to other weed control methods. Therefore, maize should be planted at 75 × 50 cm with or without jackbean and sprayed with Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW as this gave the maximum values.

**Keywords:** cucumber, jackbean, maize, propaben, superunion

## 1 Introduction

Maize (*Zea may* L.) is the third most important cereal crop in the world, after rice and wheat (IITA, 2009). The crop is an important cereal crop cultivated in all the agro-ecological zones of Nigeria. It was recently reported that about 1.07 billion tonnes of maize was produced from over 160 million hectare worldwide in 2016 (Statista, 2017). It was further noted that the United States of America had the highest annual production figure of about 385 million tonnes representing about 36.7% of the world,s total, followed by China (20%), Brazil (8.72%), European Union (5.75%), Argentina (3.57%), Ukraine (2.67%), India (2.48%), Mexico (2.48%), Russia (1.48%), South Africa (1.39%), Canada (1.26%), Indonesia (0.97%), Phillipines (0.75%), Serbia (0.71%), Nigeria (0.69%) and Ethiopia (0.60%). Earlier, about 870 million tonnes of maize grains was produced from more than 160 million hectares of farm all over the world while 9 million tonnes was produced from 4.3 million ha in Nigeria in 2012 (FAOSTAT, 2013). An estimated 4.2 million hectares was however harvested in 2013 with an average yield of 2 MT.ha$^{-1}$ in the country (Kasim et al., 2014). Maize is an important component of the diet of many Africans and a veritable source of carbohydrate, protein, vitamin B and minerals while constituting 25% of the food intake in Nigeria (Akanya et al., 1991, IITA, 2007, Uche, 2014). The grain contains approximately 76 to 88% carbohydrate, 6.10–15% protein, 4% ether extract, 2% crude fiber, 0.25% lysine, 0.18% methionine, 0.01% calcium and 0.09% available phosphorus and 3434 Kcal/kg of metabolizable

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energy (Job, 1993). Every part of maize plant viz the grain, leaves, stalk, tassel, and cob has economic value (IITA, 2009).

Cucumber (*Cucumis sativus* L.) is a widely cultivated creeping cucurbit plant produced in many parts of the world (Paleo, 2015) with the United States of America being the fourth largest producer, after China, India, and Russia (Davis, 2017). In 2016, the total global production of cucumber was 80.4 million tonnes with China, Russia, Turkey and Iran contributing about 76.9%, 2.48%, 2.25% and 2.12%, respectively. Africa, Nigeria inclusive, only produced about 0.65% of the world total cucumber (Tridge, 2018).The crop is normally cultivated at a population of 98,838 to 222,386 plants per ha., while reaching 370, 644 plants per ha. in some cases. Cucumber requires a well drained loam to sandy loam soil with high organic matter (Motes, 1977: OSulhran, 1980).

Jackbean (*Canavalia ensiformis* L.), a leguminous plant native to Central and South America is grown in the Tropics, usually on a small scale (Oropeza et al., 1993). Jackbean is a minor legume in Nigeria and other West African countries, usually grown as an ornamental plant and sometimes as a snake repellant and for soil improvement by fixing Nitrogen in the soil (Akande et al., 2014). Production areas also include Asia, Latin America and India (Akpapunam and Sefa–Dedeh, 1997). There is paucity of information on specific global and local production volumes because the plant is not in large-scale commercial cultivation (Wikipedia, 2018).

Maize production is dominated by small holder farmers using traditional manual methods that are fraught with drudgery, use of simple and low input technology, resulting in low land and labour productivity (FAO, 1999). Low soil fertility and the limited use of fertilizers especially nitrogen constitute problems of maize production in sub-Saharan Africa. Also, periodic drought caused by irregular rainfall distribution reduces maize yields by an average of 15% each year (IITA, 2009; Imoloame and Omolaiye, 2016). Oyewole and Ibikunle (2010) observed that weed interference would be a great challenge to maize production, with devastating effects. Besides direct effects in the form of competition with crops for space, nutrients and solar radiation, weeds harbour diseases and pests, increase cost of production and adversely affect the physical state of family members, especially where manual weeding is the common practice (Badmus et al., 2006; Williams, 2010; Oyewole and Ibikunle, 2010). Control of weeds from the fields of maize is, therefore, very essential for obtaining good crop harvest. Weed control practices in maize resulted in 77 to 96.7% higher yield than weed check (Khan et al., 1998).The study hypothesized that weed pressure respond differently to different weed control. Therefore, there is need to look for intervention that will reduce weed infestation in maize production and increase the growth and establishment of maize.

## 2 Material and methods

Field trials were conducted in the early cropping seasons at the Teaching and Research farm of Federal University of Agriculture, Alabata road, Abeokuta (7° 20′ N, 3° 23′ E at altitude of 159 m above sea level) in the forest – savanna transition agroecological zone of south western Nigeria during the early wet seasons of 2014, 2015 and 2016. Agrometeorological data which reflected the rainfall pattern for the three years and temperature are

**Table 1** Monthly weather data during the experiment

| | Mean temperature | | | Total rainfall | | |
|---|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2014 | 2015 | 2016 |
| Jan | 28.9 | 28.9 | 28.1 | 8.2 | 0.0 | 32.0 |
| Feb | 29.3 | 29.3 | 30.3 | 15.5 | 51.3 | 0.0 |
| Mar | 28.8 | 28.8 | 29.5 | 149.1 | 66.8 | 150.3 |
| Apr | 28.2 | 28.2 | 29.2 | 87.2 | 69.0 | 68.2 |
| May | 27.8 | 27.8 | 29.0 | 113.8 | 60.4 | 226.2 |
| June | 27.4 | 27.4 | 26.7 | 116.5 | 164.9 | 150.5 |
| July | 26.6 | 26.6 | 26.3 | 90.7 | 65.6 | 65.2 |
| Aug | 25.6 | 25.6 | 25.7 | 92.7 | 29.4 | 63.6 |
| Sept | 26.3 | 26.3 | 26.9 | 160.8 | 165.1 | 229.0 |
| Oct | 26.3 | 26.3 | 27.6 | 205.9 | 159.1 | 155.4 |
| Nov | 27.5 | 27.5 | 28.0 | 17.6 | 16.6 | 5.9 |
| Dec | 27.9 | 26.1 | 22.5 | 0.0 | 0.0 | 0.0 |

**Table 2** Physico chemical properties of soil from 0–15 cm depth at the experimental sites

| Physico-chemical properties | Level of composition | | |
|---|---|---|---|
| Soil properties | 2014 | 2015 | 2016 |
| Particle size | | | |
| Sand ($g.kg^{-1}$) | 832.0 | 802.0 | 802.0 |
| Clay ($g.kg^{-1}$) | 140.0 | 148.0 | 180.0 |
| Silt ($g.kg^{-1}$) | 28.0 | 50.0 | 18.0 |
| pH | 5.1 | 5.9 | 4.3 |
| Organic carbon ($g.kg^{-1}$) | 39.9 | 18.1 | 22.3 |
| Exchangeable acidity ($cmol.kg^{-1}$) | 1.4 | 1.5 | 2.6 |
| Total nitrogen ($g.kg^{-1}$) | 14.1 | 13.1 | 19.9 |
| Exchangeable bases | | | |
| Na ($cmol.kg^{-1}$) | 0.5 | 0.5 | 0.6 |
| K ($cmol.kg^{-1}$) | 0.5 | 0.4 | 0.4 |
| Ca ($cmol.kg^{-1}$) | 0.3 | 0.3 | 0.3 |
| Mg ($cmol.kg^{-1}$) | 0.2 | 0.2 | 0.2 |
| Available P ($mg.kg^{-1}$) | 41.0 | 40.0 | 39.0 |

represented in Table 1. Details of analysis of soils are contained in Table 2.

In this study, there were six main plot treatments (Cropping pattern) viz sole maize at interow and intrarowspacings of 75 × 50 cm and 100 × 37.5 cm and their intercrop with either cucumber or jackbean at respective intra row spacings of 75 or 50 cm on rows equidistant from maize rows. In addition, there were eight sub – plot treatments of weed control methods which included; Propaben at 2.0 kg $a.i{\cdot}ha^{-1}$, Propaben at 1.6 kg $a.i{\cdot}ha^{-1}$, Propaben at 1.6 kg $a.i{\cdot}ha^{-1}$ fb SHW, Superunion at 2.0 kg $a.i{\cdot}ha^{-1}$, Superunion at 1.6 kg $a.i{\cdot}ha^{-1}$, Superunion at 1.6 kg $a.i{\cdot}ha^{-1}$ fb SHW, Hoe weeding at 3 and 6 weeks after sowing (WAS) and Weedy check. Propaben is a commercial formulated mixtures of metolachlor 200 $g.litre^{-1}$ with prometryne 200 $g.litre^{-1}$, while Superunion is commercial formulated mixtures of acetochlor, 38% with prometryne 13%. All treatments in different combinations were laid out in a split – plot design with Randomised Block arrangement.

The land at the experimental site was ploughed twice and harrowed once at two weeks later with tractor mounted equipment. The site was marked out into main plots and sub plots before planting. Maize seeds were sowed at 3 to 4 seeds per hill at spacings indicated earlier according to the treatments. Maize plants were thinned to two plants. $stand^{-1}$ at 2 weeks after sowing (WAS) to give a population of 53,333 $plants.ha^{-1}$. Intercropped cucumber and jackbean were each planted in rows between and equidistant to the rows of the maize according to the treatments. NPK 15-15-15 fertilizer was applied at the rate of 400 $kg.ha^{-1}$ at 3WAS while Urea (46.0% N) was also applied at the rate of 100 $kg.ha^{-1}$ at 6 WAS. The fertilizers were applied as side dress at about 6 cm to maize stands. The preemergence herbicides products, Propaben and Superunion were applied one day after planting to the appropriate plots with CP3 knapsack.

Data collected on shoot dry matter and yield were subjected to analysis of variance while significant means were separated using the New Duncan`s Multiple Range Test at 5% probability level.

## 3 Results and discussion

### *3.1 Maize shoot dry weight*

Cropping pattern had significant effect on maize shoot dry weight at 9 and 12 WAS in 2014 and 2016 (Table 3). Sole maize planted at 75 × 50 cm spacing had significantly higher dry weight compared with all the other cropping patterns at 9 WAS. Similarly the sole maize at 75 × 50 cm and maize intercropped with cucumber at 100 × 37.5 cm spacing produced shoot dry weight comparable to the maximum of the maize intercropped with jackbean (215 $kg.ha^{-1}$) at 75 × 50 cm which was significantly higher than the maize intercropped with cucumber (139 $kg.ha^{-1}$) at 75 × 50 cm and the sole crop maize spacrd at 100 × 37.5 cm (146 $kg.ha^{-1}$ at 12 WAS). In 2016, maize intercropped with cucumber at 100 × 37.5 cm at 9 and 12 WAS and the sole crop at 9WAS produced maize shoot dry weight comparable to the maximum obtained from the sole maize at 75 × 50 cm and the intercrop with jackbean.

The weed control treatments had significant effect on maize shoot dry weight in all the trials except at 6 WAS in 2014. All the weed control methods resulted in significantly higher shoot dry weights than the weedy check at 9 and 12 WAS in 2014 and 2016 as well as at 12 WAS in 2015. Similar shoot dry weights were received from all the weed control methods at 9 WAS in 2014, 12 WAS in 2015 and at 6 and 9 WAS in 2016. At 12 WAS in 2014, maize plants from the plots treated with Superunion at 1.6 kg a.i·ha$^{-1}$ fb SHW produced shoot weight comparable to the maximum obtained from the maize of the corresponding Propaben treatment (227 kg. ha$^{-1}$) and higher than 150 kg.ha$^{-1}$ of the plots hoe weeded twice. In 2015, all the weed control methods with the exception of Superunion at 1.6 kg a.i·ha$^{-1}$ alone caused significant increase in maize shoot dry weight compared with the weedy check at 9 WAS. In 2016, among the weed control methods, two hoe weedings resulted in values comparable to the maximum of Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW.

### *3.2 Weed cover score*

Cropping pattern had significant effect on weed cover score at 6 and 12 WAS in 2014, at 12 WAP in 2015, as well as 9 and 12 WAS in 2016 (Table 4). In 2014, maximum weed cover scores were obtained on the plots of sole maize at 100 × 37.5 cm spacing and sole maize at 75 × 50 cm spacing at 6 and 12 WAS, respectively. Furthermore at 6 WAS, the values obtained on the plots of maize at 100 × 37.5 cm intercropped with jackbean was also lower than those of plots of sole maize at 75 × 50 cm spacing and the intercrop with the two cover crops. At 12 WAS, weed cover scores on the plots of maize planted at 100 × 37.5 cm and intercrop with jackbean and that at 75 × 50 cm spacing with cucumber were similar, and lower than those of sole maize at both spacings. The plots of maize at 75 × 50 cm intercropped with cucumber also had lower value than that of the corresponding one with maize at 100 × 37.5 cm.

In 2015 at 12 WAP, the highest and lowest weed cover score was recorded on sole maize planted at 75 × 50 cm and maize at 100 × 37.5 cm intercropped with jackbean, respectively.

At 9 WAP in 2016, the highest weed cover was recorded on sole maize at 100 × 37.5 cm, while at 12 WAP in same year the highest weed cover was recorded on maize at 75 × 50 cm intercropped with jackbean. At both stages of

**Table 3** Effects of cropping pattern and weed control treatments on maize shoot dry matter (kg.ha$^{-1}$) in 2014, 2015 and 2016 early wet season at Abeokuta

| Treatment | Maize shoot dry matter (kg.ha$^{-1}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cropping pattern (CP) | 2014 | | | 2015 | | | 2016 | | |
| Maize intercropped with | 6 WAS | 9 WAS | 12 WAS | 6 WAS | 9 WAS | 12 WAS | 6 WAS | 9 WAS | 12 WAS |
| 100 × 37.5 cm cucumber | 49 | 95b | 202ab | 47 | 120 | 195 | 21 | 81ab | 106ab |
| 100 × 37.5 cm jack bean | 50 | 108b | 165bc | 51 | 113 | 192 | 16 | 63bc | 98b |
| 100 × 37.5 cm sole maize | 42 | 116b | 146c | 48 | 119 | 191 | 23 | 80ab | 97b |
| 75 × 50 cm cucumber | 50 | 108b | 139c | 53 | 105 | 177 | 21 | 55c | 96b |
| 75 × 50 cm jack bean | 59 | 122b | 215a | 74 | 143 | 237 | 25 | 93a | 139a |
| 75 × 50 cm sole maize | 57 | 175a | 209ab | 73 | 140 | 231 | 26 | 88a | 143a |
| SED (CP) | 12.19ns | 18.11 | 19.44 | 13.19ns | 16.46ns | 20.02ns | 5.93ns | 10.04 | 17.12 |
| Weed control method (WC) | | | | | | | | | |
| Propaben at 2.0 kg a.i·ha$^{-1}$ | 49 | 125a | 190abc | 60a | 133ab | 201a | 22a | 82a | 106b |
| Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW | 63 | 138a | 227a | 62a | 163a | 233a | 21a | 101a | 155a |
| Propaben at 1.6 kg a.i·ha$^{-1}$ | 52 | 120a | 184bc | 54ab | 130ab | 202a | 26a | 74a | 108b |
| Superunion at 2.0 kg a.i·ha$^{-1}$ | 54 | 134a | 177bc | 79a | 102ab | 227a | 21a | 71a | 105b |
| Superunion at 1.6 kg a.i·ha$^{-1}$ fb SHW | 63 | 143a | 214ab | 57ab | 144ab | 214a | 26a | 87a | 121b |
| Superunion at 1.6 kg a.i·ha$^{-1}$ | 46 | 116a | 176bc | 56ab | 106bc | 211a | 22a | 74a | 120b |
| Hoe weeding at 3 and 6 WAS | 50 | 117a | 152c | 61a | 141ab | 239a | 25a | 82a | 128ab |
| Weedy check | 30 | 73b | 114d | 33b | 66c | 104b | 12b | 43b | 64c |
| SED (WC) | 11.70ns | 18.97 | 18.63 | 10.96 | 23.78 | 32.03 | 4.42 | 13.4 | 14.85 |
| SED (CP XWC) | 29.45ns | 47.09ns | 46.89ns | 28.36ns | 56.93ns | 76.07ns | 32.30ns | 11.74ns | 38.09ns |

SED – standard error of difference; WAS – weeks after sowing; SHW – supplementary hoe weeding; ns – not significant

**Table 4** Effects of maize cropping pattern and weed control treatments on weed cover score in 2014, 2015 and 2016 early wet seasons at Abeokuta

| Treatment | Weed cover score | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cropping pattern (CP) | 2014 | | | 2015 | | | 2016 | | |
| Maize intercropped with | 6 WAS | 9 WAS | 12 WAS | 6 WAS | 9 WAS | 12 WAS | 6 WAS | 9 WAS | 12 WAS |
| 100 × 37.5 cm cucumber | 5.8 bc | 6.4 | 7.8 abc | 4.2 | 5.6 | 6.2 ab | 4.5 | 6.0ab | 6.9a |
| 100 × 37.5 cm jack bean | 4.5c | 5.6 | 6.3bc | 3.8 | 5.1 | 5.5 d | 3.5 | 5.3ab | 6.0ab |
| 100 × 37.5 cm sole maize | 7.1 a | 6.6 | 8.3 ab | 3.9 | 5.8 | 6.4 ab | 4.8 | 6.4a | 7.3a |
| 75 × 50 cm cucumber | 6.1 ab | 6.7 | 6.1c | 4.1 | 5.8 | 5.9 cd | 3.2 | 4.0b | 4.5b |
| 75 × 50 cm jack bean | 6.0 ab | 6.9 | 7.2 abc | 4.2 | 5.8 | 6.5 ab | 4.2 | 6.2a | 7.5a |
| 75 × 50 cm sole maize | 6.3ab | 6.9 | 8.5a | 4.0 | 5.9 | 6.7a | 3.7 | 4.9ab | 6.0ab |
| SED (CP) | 0.6* | 0.7ns | 0.8* | 0.28ns | 0.4ns | 0.31** | 0.6ns | 0.9* | 1.1* |
| Weed control method (WC) | | | | | | | | | |
| Propaben at 2.0 kg a.i·ha$^{-1}$ | 5.3c | 7.1b | 7.5bc | 3.6c | 7.1b | 7.5b | 3.4bc | 6.0b | 7.0bc |
| Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW | 5.8bc | 4.4c | 6.2c | 3.5cd | 4.4c | 3.7d | 3.0c | 2.7c | 3.8d |
| Propaben at 1.6 kg a.i·ha$^{-1}$ | 5.7bc | 7.2b | 7.7b | 4.3b | 7.2b | 7.3b | 3.6bc | 6.1b | 6.9bc |
| Superunion at 2.0 kg a.i·ha$^{-1}$ | 5.3c | 6.9b | 7.8b | 3.5cd | 6.9b | 6.8b | 3.3bc | 5.7b | 6.6bc |
| Superunion at 1.6 kg a.i·ha$^{-1}$ fb SHW | 5.4c | 4.6c | 6.9c | 3.4cd | 4.6c | 3.9d | 3.5bc | 3.1c | 4.3cd |
| Superunion at 1.6 kg a.i·ha$^{-1}$ | 5.5bc | 6.8b | 7.4b | 4.4b | 6.8b | 7.5b | 3.7b | 6.6b | 7.5b |
| Hoe weeding at 3 and 6 WAS | 6.3b | 4.7c | 6.3c | 2.9d | 4.7c | 4.9c | 3.3bc | 2.9c | 4.3d |
| Weedy check | 7.8a | 9.7a | 9.7a | 8.3a | 9.7a | 9.9a | 7.5a | 9.1a | 9.2a |
| SED (WC) | 0.4** | 0.4** | 0.4** | 0.3** | 0.4** | 0.4** | 0.3** | 0.5** | 0.4** |
| SED (CP × WC) | 1.2ns | 1.2* | 1.3* | 0.8ns | 1.1ns | 1.0ns | 0.9ns | 1.5ns | 1.5ns |

SED – standard error of difference; WAS – weeks after sowing; SHW – supplementary hoe weeding; ns – not significant

growth, the lowest weed cover was recorded on maize at 75 × 50 cm intercropped with cucumber.

The weed control treatments had significant effect on weed cover score at 6, 9 and 12 WAS in all the trials. In all cases, the weed control methods consisting of herbicides and two hoe weedings reduced weed cover scores compared with the weedy checks. In 2014, all the herbicides treatments generally caused lower weed cover score at 6 WAS than hoe weeding. In 2016, all the herbicide treatments resulted in scores comparable to the hoe weeded control at 6 WAS. However, at 9 WAS in all the years and 12 WAS in 2014 and 2016, the plots sprayed with the two herbicides, each at 1.6 kg a.i·ha$^{-1}$ followed by supplementary hoe weeding had cover scores comparable to those of two hoe weedings while those with Propaben at 2.0 kg a.i.·ha$^{-1}$ also had values comparable to the lowest of two hoe weedings at 12 WAS in 2014. However, at 12 WAS in 2015, the herbicide treatments with SHW caused lower values of weed cover scores than two hoe weedings.

### *3.3 Cob length*

Cropping pattern of maize had significant effect on total cob length in 2015 only. The sole crop of maize planted at 100 × 37.5 cm produced value (12.1 cm) comparable to the maximum (12.3 cm) for the crop spaced at 75 × 50 cm intercropped with jackbean and higher than the minimum (10.5 cm) of that at 100 × 37.5 cm spacing intercropped with cucumber. The weed control treatments had significant effect on total cob length in 2014 and 2015 (Table 5). In 2014, the plots treated with Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW produced cobs with total length (13.9 cm) comparable to the maximum of those with Super union at 1.6 kg a.i·ha$^{-1}$ fb SHW (14.2 cm) and significantly higher than those of the cobs produced on the plots left weed infested throughout (12.6 cm). In 2015, the values of total length of cobs produced on plots with the weed control methods including two hoe weedings (11.3–12.1 cm) except Propaben at 2.0 kg a.i·ha$^{-1}$ were similar and higher than that of the weedy check (10.0 cm) (Table 5).

### *3.4 Cob yield*

Cropping pattern had significant effect on cob yield in 2015 and 2016 (Table 5). Cob yields were obviously lower in 2015 than in 2014 and 2016 in the study. Sole maize at 75 × 50 cm and that spaced at 100 × 37.5 cm intercropped with jackbean produced cob yields comparable to the maximum of maize at 75 × 50 cm spacing intercropped with jackbean and the sole one at 100 × 37.5 cm spacing in 2015. In the trial, the maize intercropped with cucumber at both spacings produced lower yields than the maximum. However in 2016, sole maize at 100 × 37.5 cm spacing produced cob yield comparable to the maximum of that at 75 × 50 cm spacing intercropped with jackbean but higher than the minimum of that at 100 × 37.5 cm intercropped with jackbean and at 75 × 50 cm intercropped with cucumber.

Weed control treatments had significant effect on cob yield in all the trials. In 2014, the plots with Superunion at 1.6 kg a.i·ha$^{-1}$ fb SHW (1,938 kg.ha$^{-1}$) and those hoe-weeded twice (1,901 kg.ha$^{-1}$) had values comparable to the maximum of those with Propabenat 1.6 kg a.i·ha$^{-1}$ fb SHW (2,183 kg.ha$^{-1}$) and higher than that with Super union at 1.6 kg a.i·ha$^{-1}$ alone and the weedy check which were similar. Furthermore, the high rate of the two herbicides also resulted in values lower than the maximum but obviously higher than that of the weedy check. In 2015, the plots left weed infested throughout produced the lowest cob yield (724 kg.ha$^{-1}$) while those of the other weed control methods except Propaben at 2.0 kg a.i·ha$^{-1}$ had values comparable to the maximum produced on plots with supplementary hoe weeding of herbicides (1,240 and 1,391 kg.ha$^{-1}$) and two hoe weedings (1,283 kg.ha$^{-1}$) (Table 5).

In 2016, the plots treated with Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW (2,533 kg.ha$^{-1}$) and those hoe weeded twice (2,574 kg.ha$^{-1}$) produced the highest cob yields while those with Propaben at 2.0 kg a.i·ha$^{-1}$ (1,925 kg.ha$^{-1}$) and Superunion at 1.6 kg a.i·ha$^{-1}$ fb SHW (1,899 kg.ha$^{-1}$) also produced higher values than that of the weedy check (1,496 kg.ha$^{-1}$) (Table 5).

Sole maize at 75 × 50 cm spacing and the intercrop with jackbean consistently produced maximum values of growth parameters while the intercrop with cucumber had reduction growth of maize. These results were probably due to early senescence of cucumber short life cycle which resulted in the drying of the vegetative part consequently reducing ground coverage and permitting profuse weed infestation at the critical flowering stage of maize. In contrast, Jackbean had formed good ground coverage which enhanced weed suppresion in addition to better maize canopy produced by closer interrow spacing which resulted in season – long reduction of weed infestation. It was also apparent that intercropped jackbean did not adversely affect the growth of maize in this study.

**Table 5** Effects of Cropping pattern and weed control treatments on yield and yield components in maize production in 2014, 2015 and 2016 early wet seasons at Abeokuta

| Cropping pattern (CP) | Length (cm) | | | Cob yield (kg.ha$^{-1}$) | | |
|---|---|---|---|---|---|---|
| Maize intercropped with | 2014 | 2015 | 2016 | 2014 | 2015 | 2016 |
| 100 × 37.5 cm cucumber | 13.2 | 10.5c | 12.4 | 1,904 | 859.b | 1,831bc |
| 100 × 37.5 cm jack bean | 13.4 | 11.2bc | 11.7 | 1,761 | 1,092.ab | 1,446c |
| 100 × 37.5 cm sole | 14 | 12.1ab | 13 | 1,889 | 1,289.a | 2,436ab |
| 75 × 50 cm cucumber | 12.9 | 11.0bc | 11.4 | 1,558 | 818.b | 1,250c |
| 75 × 50 cm jack bean | 13.3 | 12.3a | 12.5 | 1,801 | 1,297.a | 2,581a |
| 75 × 50 cm sole | 13.3 | 11.3bc | 13 | 1,629 | 997.ab | 1,942abc |
| SED (CP) | 0.5ns | 0.43* | 0.6ns | 217.0ns | 185 | 324** |
| Weed controm method (WC) | | | | | | |
| Propaben at 2.0 kg a.i·ha$^{-1}$ | 12.9bc | 10.9bc | 12.4 | 1,577bc | 859ab | 1,925b |
| Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW | 13.9ab | 11.9ab | 12.6 | 2,183a | 1,240a | 2,533a |
| Propaben at 1.6 kg a.i·ha$^{-1}$ | 13.1bc | 11.3ab | 12.7 | 1,683abc | 961ab | 1,581bc |
| Superunion at 2.0 kg a.i·ha$^{-1}$ | 13.5abc | 11.6ab | 12.1 | 1,587bc | 1,093ab | 1,741bc |
| Superunion at 1.6 kg a.i·ha$^{-1}$ fb SHW | 14.2a | 12.1a | 12.5 | 1,938ab | 1,319a | 1,899b |
| Superunion at 1.6 kg a.i·ha$^{-1}$ | 13.1bc | 11.4ab | 11.8 | 1,762cd | 991ab | 1,605bc |
| Hoe weeding at 3 and 6 WAS | 13.5abc | 12.0ab | 12.9 | 1,901ab | 1,283a | 2,574a |
| Weedy check | 12.6c | 10.0c | 11.6 | 1,424d | 724c | 1,456c |
| SED (WC) | 0.48* | 0.57** | 0.6ns | 128.7** | 204.5* | 217.1** |
| SED (CP × Wc) | 1.2ns | 1.5ns | 1.5ns | 366.0ns | 504ns | 593.6ns |

SED – standard error of difference ; WAS – weeks after sowing; SHW – supplementary hoe weeding; ns – not significant

The wide spacing of maize at 100 × 37.5 cm could have enhanced the aggressive growth of cucumber in the intercrop which also suppressed weed growth more than jackbean at early stage which perhaps resulted into increased leaf production and the overall growth of maize. Also, the maximum shoot dry matter produced by sole maize at 75 × 50 cm spacing and the intercrop with jackbean could be attributed to narrow row spacing which must have put maize crop at a competitive advantage over weeds by reducing solar radiation to the understorey weed seedlings. This result is consistent with that reported by Das (2013) that closer row spacings enhanced the competitive ability of maize more than wider ones. It was also reported that legumes cover crops could prevent the development of weed population, control the soil disease, soil enrichment through nitrogen fixation in soil, improve soil structure, prevent absorption of nitrogen, increase the soil organic matter and supply most of N required for maximum maize yield (Clark et al., 1997 and Bayer et al., 2000). Maize at 75 × 50 cm intercropped with cucumber had shorter days to tasselling than all the other planting pattern. This was probably due to earlier completion of life cycle as a result of stress arising from early senescense of cucumber leading to serious competition between maize crop and weeds for all growth factors.

The growth and yield of maize were influenced by the weed control treatments as reflected in shoot dry matter production. Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW consistently produced maximum shoot dry matter production compared to other weed control methods. This could be attributed to the fact that the supplementary hoe weeding had enhanced the effectiveness of Propaben at the selective low rate and resulted in further reduction of late emerging weeds as earlier observed by Lagoke (2003), Badmus (2006), Gana et al. (2007) Williams (2010) and Lagoke et al. (2014). Similarly, all the weed control methods improved the vigour of maize plants while low rate of herbicides fb SHW further improved the parameter compared to the herbicide at low and high rate alone in all cases. This result further corroborates the earlier reports of Lagoke (1993), Adigun and Lagoke (2003), Badmus et al. (2006), Gana et al. (2007) and Williams (2010) that supplementary application of lower rates of the preemergence herbicide with additional hoe weeding enhanced effective weed control in maize and thereby improving crop growth.

In 2016, only maize plants on plots treated with the low rates of the two herbicide formulations fb SHW had vigour scores comparable to those hoe weeded twice at 6, 9 and 12 WAS. This result confirms that herbicides could be as effective as hoe weeding in managing weeds in maize production at the early stage of growth, up to 6WAS, but require additional weeding for acceptable crop growth and season long weed control (Adigun and Lagoke, 2003; Chikoye et al., 2005).

Lower weed cover observed on the hoe weeded plots compared to the weedy check was as a result of frequent weed removal which did not permit weed growth. Lower weed cover on the herbicide treated plots was as a result of the pre-emergence herbicide applied at planting which prevented the establishment of weed seedlings from growing. The lower weed cover on plots treated with pre-emergence herbicide plus SHW is as a result of further weed removal which enhanced early crop canopy closure and thereby smothering weeds. This is in agreement with earlier report by Osunleti et al., 2021 and 2022 who reported lower weed biomass when pre emergence herbicide is followed up by post emergence treatments. Also, Imoloame (2014) reported further suppression of late emerging weeds as a result of integrated weed management.

## 4 Conclusions

In this study, maize intercropped with jackbean at the 75 × 50 cm spacing produced the higher maize shoot dry matter, longer maize cob and higher maize cob yield compared to most cropping patterns, and therefore recommended in maize production. Among the weed control methods, application of Propaben at 1.6 kg a.i·ha$^{-1}$ fb SHW consistently resulted in maximum values of maize shoot dry matter, reduced weed cover and higher maize cob yield. Therefore, preemergence application of Propaben at 1.6 kg a.i·ha$^{-1}$ followed by hoe weeding is recommended for good maize growth.

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