Nig. J. Anim. Prod. 2018, 45(2): 247 - 255

Effect of plant spacing and intercropping with two *vigna* species on growth and yield of forage maize

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Abstract

An experiment was conducted at the Teaching and Research Farm of Abia State University, Umuahia Campus, Nigeria, from the month of May to October, 2012 to determine the effect of plant spacing on the growth and yield of forage plant, maize (Zea mays), intercropped with cowpea (Vigna unguiculata sub spp. Dekintiana) and Bambara nut (Vigna subterenea). The treatments included two plant spacings (50x50 cm and 100x100 cm) either in sole or intercropped system viz: maize-cowpea 50x50 (MC50), maize-cowpea 100x100 cm (MC100), maize-Bambara nut 50x50 (MB50), maize-Bambara nut 100x100 (MB100), sole maize 50x50 (SM50) and sole maize 100x100 (SM100). The cowpea and Bambara were planted at two seeds per hole while the maize was planted three seeds per hole. NPK 15:15:15 fertilizer was applied 4 weeks after planting (WAP) at 200 kg/ha. The results obtained showed that maize growth and yield were significantly ($P<0.05$) affected by plant spacing and intercropping. Data at week 5 showed that MC100 and MB100 both had the highest values of 382.06 cm^2 and 368.58 cm^2, respectively for leaf area, while SM100 recorded the lowest value of 190.66 cm^2. The same treatments recorded the highest ($P<0.05$) values for stem girth at weeks 5 and 7. Lowest leaf/stem ratio was 0.28 for SM100 while the highest value of 0.68 was recorded for MC50. The intercrops at closer spacing (SM50 and MC50) had similar values ($P>0.05$) for herbage yield and their values were significantly higher ($P<0.05$) than those recorded for the other treatments. Based on the findings, MC100 and MB100 had higher growth indices than the other treatments whereas the intercrops at closer spacing had higher herbage yield.

Keywords: Spacing, Intercropping, Forage maize, Vegetable cowpea, Bambara nut

Introduction

Animal agriculture is one of the most important components of global agriculture and livestock is one of the main users of the natural resources base (de Haan, 1996). Feed constraint is the most important impediment to improved livestock production in the Sub-Saharan African (SSA) countries as a result of seasonal shortages in the quantity and quality of forage from natural pastures that supply most of the feed for animals due to annual dry season (Agyemang, 2002). Appropriate technologies to improve the performance of the local animal breeds and feed resources under the traditional system are generally lacking. Intercropping cereals with forage legumes has been shown to improve both the quantity and quality of fodder (Umunna, 1995). This could improve livestock production considerably in addition to benefits in soil fertility. Feed quality of intercropped feeds is enhanced especially by the legume component with a consequent increase in livestock productivity (milk and meat).

Plant spacing is an important agronomic attribute since it is believed to have effects on light interception during which photosynthesis takes place. Good plant spacing gives the right plant density, which is the number of plants allowed on a given unit of land for optimum yield (Obi, 1991). Many vegetative and yield variables of crops are potentially influenced by competition of the plant with the second crop in an intercropping system and by competition with other plants of the same species. This influence may be affected by changes in plant population density. Reasons for cereal-legume intercropping are varied, depending on individual farmer production goal, but invariably include more crops at harvest, improved fodder quality and yields of the companion cereal crop, increased soil fertility and insurance against total crop failure. Maize (*Zea mays*), which is the third most important cereal crop of the world, surpassed only by wheat and rice (IITA, 2005), is an important dual purpose crop used in human diet and animal feed. Maize has the potential to supply large amounts of energy-rich forage for animal diets, and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum (Dahmardeh, 2009). Bambara groundnut (*Vigna subterranean* (L) Verdc.) is a legume crop of the family Papilonaceae and indigenous to Africa. It is one of the most important sources of protein for Africans (Brough and Azam-Ali, 1992), comparable to cowpea, groundnut and soybean. The leaves are suitable for animal grazing because they are rich in nitrogen and phosphorus (Rassel, 1960). The haulms were found to be palatable (Doku and Karikari, 1971) and are an important source of livestock feed during the dry season. In the South-Eastern Nigeria, the traditional farming systems have evolved the vegetable cowpea which shows remarkable adaptation to the prevailing humid climatic condition (Ezueh and Nwoffiah, 1984). Two genotypes of vegetable cowpea exist in the farming systems of South-Eastern Nigeria namely those with climbing habit called *V. unguiculata* subspecies *sequipedalis* (Redden, 1981) commonly called "Akidienu" and those with prostrate habit referred to as *V. unguiculata* subspecies *dekintiana* and *mensensis* (Steele and Mehra, 1980) commonly known as "Akidiani". Most of the information on cowpea in Nigeria is on the grain cowpea. This study aims at evaluating the effect of plant spacing and intercropping with vegetable cowpea and Bambara nut on the growth and yield of forage maize.

Materials and methods

The experiment was conducted at the Teaching and Research Farm of Abia State University Umuahia Campus from the month of May to October, 2012. The routine soil analysis of 0-30cm depth (Mylavapus and Kennelley, 2002) showed that it had pH (H_2O) 4.50, total nitrogen (%) 0.06, organic carbon (%) 0.32, available phosphorus (mg/kg) 16.00, exchangeable K (cmol/kg) 0.035, exchangeable Mg (cmol/kg) 1.11, Clay (%) 11.40, Silt (%) 10.80 and Sand (%) 77.80. The treatments included two plant spacing (50x50 cm and 100x100 cm) either in sole or intercropped system, viz: maize-cowpea 50x50 (MC50), maize-cowpea 100x100 cm (MC100), maize-bambara 50x50 (MB50), maize-bambara 100x100 (MB100), sole maize 50x50 (SM50), sole maize 100x100 (SM100). Three seeds of maize variety Oba Super 2 sourced from the National Seed Store, Umudike were sown per hole. The legume was sown centrally in-between the maize stands along the rows at two seeds per hole. NPK 15:15:15 fertilizer was applied 4 weeks after planting (WAP) at 200 kg/ha.

Data collection

Measurement of plant height

Measurement of the height of the maize was done by measuring from the base of the plant to where the last leaf on the stem emerges with the aid of a meter rule on ten randomly selected stands per plot.

Measurement of leaf length

Leaf length of the maize was done by measuring the length of the leaf from its tip to the ligule. This was done with the aid of a meter rule on ten stands that were randomly selected from each plot.

Measurement of leaf width

Measurement of leaf width of the maize was done by measuring the length of the leaf half way and at that point measuring its width. This was done with the aid of a 30cm meter rule on ten stands that were randomly selected from each plot.

Determination of leaf/stem ratio

This was determined from six maize plants per replicate randomly selected from the middle rows to avoid border effect. The plants were separated into leaf (blade and sheath) and stem (stem, husk and tassel) fractions and each fraction was immediately weighed. The leaf/stem ratio was calculated as follows:

$$\frac{\text{Weight of leaf fraction}}{\text{Weight of stem fraction}}$$

Determination of dry/green leaf ratio

This was taken from six plants from each replicate by dividing the dry leaves (leaves that are more than 50% discoloured) to green leaves (leaves that are 50% and above still green).

Determination of ear weight

The weight of the ear yield from six plants from each replicate was measured and the average taken to determine the yield per plant.

Determination of cob and husk weights

The harvested ears from each replicate were de-husked and the husks and cobs were weighed separately. Their means were also taken to determine their weights per plant.

Determination of husk/cob ratio

This was taken from six plants from each replicate by dividing the husk fraction of the corn ears by the cob fraction.

Estimation of total yield

The estimation of total yield was carried out by deriving the dry weight of one plant averaged from six plants from each replicate and multiplying it by the plant population/ha. Plant population was determined as follows:

$$\text{Plant population} = \frac{10{,}000\text{m}^2}{\text{Spacing}}$$ **(Aikins *et al.*, 2012)**

The dry matter percentage was estimated as:

$$\text{Dry matter percentage} = \frac{\text{Weight of dry sample}}{\text{Weight of fresh sample}} \times 100$$

Dry matter yield = dry matter percent x fresh sample from fresh weight of six plants which afterwards was extrapolated into kilograms per hectare.

Data were subjected to analysis of variance using the Statistical Package for Social Sciences (SPSS) version 17 and means were separated using Duncan's Multiple Range Test (Duncan, 1955).

Results and discussions

The effect of spacing and intercropping on the growth indices of maize at week 5 are shown on Table 1.

Table 1: Effect of Spacing and Intercropping on Growth Indices of Maize at Week 5

Parameters	Treatments						
	SM100	SM50	MC100	MC50	MB100	MB50	SEM
Leaf no	7.50	7.22	6.72	7.00	7.56	6.95	0.67
Plant spread (cm)	51.11^{c}	56.89^{bc}	70.66^{a}	63.06^{abc}	67.61^{ab}	57.67^{bc}	5.88
Plant height (cm)	17.74^{ns}	20.65^{ns}	17.47^{ns}	19.49^{ns}	20.69^{ns}	19.50^{ns}	1.87
Stem girth (cm)	3.74^{c}	4.11^{c}	5.66^{a}	4.34^{bc}	5.36^{a}	5.00^{ab}	0.46
Leaf Length (cm)	53.50^{b}	55.11^{ab}	64.61^{a}	58.83^{ab}	59.33^{ab}	55.89^{ab}	5.47
Leaf width (cm)	3.94^{b}	4.94^{ab}	6.72^{a}	6.83^{a}	7.25^{a}	6.22^{ab}	0.64
Leaf area (cm^2)	190.66^{b}	225.19^{ab}	382.06^{a}	342.12^{ab}	368.58^{a}	295.85^{ab}	33.64

***abc: Means on the same row with different superscripts are significant (P<0.05)**
SM 100 = Sole maize at 100cm spacing; SM 50 = Sole maize at 50cm spacing
MC 100 = Maize/Akidi at 100cm spacing; MC 50 = Maize/Akidi at 50cm spacing
MB 100 = Maize/Bambara 100cm spacing; MB 50 = Maize/Bambara 50cm spacing

There were significant differences (P<0.05) in all the parameters measured except leaf number and plant height. Sani *et al*. (2011) reported in an experiment with maize planted at 75cm spacing that there were no significant differences in plant height. Ibeawuchi *et al*. (2008) observed that there were no significant differences in plant height of maize hybrid in an experiment involving four different plant spacings except at the 6th week when significant differences (P<0.05) were observed. Plant height as a plant growth character and yield index is vital for maize. This is because the taller a plant, the higher the amount of light energy absorbed by such plant and invariably, the higher the rate of photosynthesis and consequently the amount of assimilate produced by the leaves (Olakojo and Iken, 2001).

Values for plant spread at the 5th week ranged from 51.11cm for SM 100cm to 70.66cm for MC 100cm spacing and those for stem girth ranged from 3.74cm for sole maize to 5.66cm for MC 100cm. The intercrops with wider spacing had the highest stem girth while the sole plots with closer spacing had the lowest stem girths. This trend was also observed at the 7th week (Table 2) while values for this parameter were similar (P>0.05) at the 9th week. Futuless *et al*. (2010) observed lower stem girth at closer spacing than at wider spacing. This phenomenon might be due to closer spacing that might lead to a degree of etiolation.

Table 2: Effect of Spacing and Intercropping on Growth Indices of Maize at Week 7

Parameters	Treatments						
	SM100	SM50	MC100	MC50	MB100	MB50	SEM
Leaf no	10.11^{ns}	10.94^{ns}	10.89^{ns}	10.83^{ns}	11.17^{ns}	11.16^{ns}	1.02
Plant spread (cm)	83.50^{b}	90.61^{ab}	98.61^{a}	94.50^{ab}	98.17^{a}	92.28^{ab}	8.70
Plant height (cm)	42.78^{b}	52.39^{ab}	58.22^{a}	58.28^{a}	60.61^{a}	59.06^{a}	5.41
Stem girth (cm)	8.11^{c}	8.39^{bc}	9.11^{ab}	8.33^{bc}	9.33^{a}	8.44^{bc}	0.80
Leaf Length (cm)	78.67^{ns}	80.95^{ns}	84.11^{ns}	80.72^{ns}	83.89^{ns}	80.44^{ns}	7.57
Leaf width (cm)	8.22^{b}	13.22^{a}	9.89^{ab}	8.61^{b}	9.89^{ab}	9.39^{ab}	1.03
Leaf area (cm^2)	552.43^{b}	928.47^{a}	712.87^{ab}	592.45^{ab}	705.31^{ab}	642.11^{ab}	74.17

***abc: Means on the same row with different superscripts are significant (P<0.05)**
SM100 = Sole maize at 100cm spacing; SM50 = Sole maize at 50cm spacing
MC100 = Maize/Akidi at 100cm spacing; MC50 = Maize/Akidi at 50cm spacing
MB100 = Maize/Bambara 100cm spacing; MB50 = Maize/Bambara 50cm spacing

The findings from this study corroborates earlier report that narrow spacing in maize encourages plant growth with weak stems and commented that maize plants with weaker stems are more prone to lodging (Rowland, 1993). Stem girth may also have an implication on plant leaf/stem ratio which is an important forage quality attribute since the stem fraction of a plant is less nutritious than the leaf fraction. Any agronomic practice that improves the leaf/stem ratio of forage plants should be encouraged.

Furthermore, at week 5, SM 100cm had significantly lower leaf length, leaf width and leaf area than MC 100cm and similar values with the other treatments (Table 1). Looking at the figures visually, it appeared that the intercrops at wider spacing had higher values for these parameters. The trend was maintained at the 7th week while the values became insignificant at the 9th week). Also, at the 7th week, all the intercrops had similar (P>0.05) plant heights that were higher (P<0.05) than those of the sole plots.

These differences could be as a result of soil moisture being retained in the intercrops compared with the wide spacing (100cm) of the sole maize which would lose more soil water through evaporation. Afuwakwa and Crookston (1984) pointed out that soil moisture is an important factor that affects leaf area of plants. At the vegetative stage of week 5, the maize plants planted solely probably did not have enough spread to combat the loss of soil moisture. However, by the 9th week (Table 3) these leaf parameters were insignificant (P>0.05) across the treatments indicating sufficient ground cover and hence much reduced water loss from the soil.

Table 3: Effect of Spacing and Intercropping on Growth Indices of Maize at Week 9

Parameters	Treatments						
	SM100	SM50	MC100	MC50	MB100	MB50	SEM
Leaf no	11.16^{ns}	11.50^{ns}	11.78^{ns}	11.50^{ns}	12.11^{ns}	11.55^{ns}	1.08
Plant spread (cm)	87.39^{b}	91.45^{b}	108.00^{a}	97.00^{ab}	97.89^{ab}	95.39^{ab}	9.04
Plant height (cm)	58.61^{ns}	84.11^{ns}	97.39^{ns}	97.61^{ns}	99.33^{ns}	88.22^{ns}	9.74
Stem girth (cm)	7.39^{ns}	7.67^{ns}	8.17^{ns}	7.50^{ns}	8.67^{ns}	7.72^{ns}	0.78
Leaf Length (cm)	80.95^{ns}	89.28^{ns}	92.06^{ns}	91.00^{ns}	97.45^{ns}	93.61^{ns}	8.61
Leaf width (cm)	8.50^{ns}	9.11^{ns}	9.78^{ns}	8.72^{ns}	10.00^{ns}	8.94^{ns}	0.87
Leaf area (cm^2)	603.16^{ns}	701.30^{ns}	765.34^{ns}	677.69^{ns}	826.31^{ns}	716.29^{ns}	70.99

***abc: Means on the same row with different superscripts are significant (P<0.05)**
SM100 = Sole maize at 100cm spacing; SM50 = Sole maize at 50cm spacing
MC100 = Maize/Akidi at 100cm spacing; MC50 = Maize/Akidi at 50cm spacing
MB100 = Maize/Bambara 100cm spacing; MB50 = Maize/Bambara 50cm spacing

This result was similar to that of Filho (2000) who did not observe any significant difference in leaf area of maize plants from sole maize plots and maize cowpea intercrops. Twala and Ossom (2004) also did not find any significant differences in leaf area between maize monocrop and maize intercropped with sugar bean or groundnuts. All the yield indices investigated also showed significant differences (P<0.05). Leaf/stem ratio was highest for MC 50cm and lowest for MB 100cm. Though significant differences were observed, the values for this parameter were rather satisfactory since the values were generally above 0.50. This trend may also be explained by the non-significance observed in plant height at this vegetative stage, an indication of uniform growth. With the gradual growth of plants, the ratio of leaf to stem will change such that there is more stem and less leaf (Rezaeifard *et al.*, 2010). The leaf/stem ratio data also indicate that all the treatments had higher amount of leaves which are preferred by livestock (Vern *et al.*, 2000).

The highest dry to green leaf ratio was recorded for MC 50cm. This may be as a result of the close spacing which resulted in higher plant density and hence greater competition for soil nitrogen. It was also observed that the cowpea vines for this treatment entangled themselves on the maize plants causing great stress for the maize plants. All these might have resulted in wilting of leaves.

Ear weight/plant and cob weight/plant were higher for MC 100cm and MB 100cm with 225.56g and 260.0g recorded respectively. This might be due to the fact that they both recorded higher plant spread, stem girth, leaf length, leaf width and leaf area. The lowest values for these parameters were recorded for MC 50cm. The high dry to green leaf ratio for MC 50cm might have played a contributory role to this situation since only photosynthetically active leaves would contribute in the production of soluble sugars which are used by the plant for reproductive development. According to Standhill (1981), crop physiologists have established that the increased solar interception achieved by the large and larger living crop canopies can largely explain the high yield levels in crop production. Krishna *et al*. (1998) and Ayisi *et al*. (2001) have reported greater green fodder yield of sorghum when grown with cowpea. Heathcliffe (2008) hinted that photosynthetic activity could also be increased in maize-legume mixtures by increasing the mixture-canopy surface area, resulting in increased dry matter accumulation. Ghosh *et al.* (2004) also reported that maximum resource potential can be obtained through use of different legumes with maize. The higher yields of grass in grass-legume mixture are usually attributed to increased nitrogen supply to the grass through mineralization of N from shed legume leaves, dead roots and decaying nodules which are of lower carbon:nitrogen ratio than grass residue (Whitney, 1977).

All the treatments at 50cm spacing had similar values for herbage yield and their values were higher (P<0.05) than those recorded for the other treatments. This is very likely as a result of a greater population of plants at the closer spacing. The yield of a crop is a function of a number of factors and processes such as light intercepted by the canopy, metabolic efficiency of plants, translocation efficiency of photosynthates from leaves to economic parts and the genetic makeup of the crops (Doku, 1977). Also, it is recognized that the photosynthetic capacity of the plant determines the overall productivity; the extent of development of each yield character is also dependent on the interrelationship between the various yield components. More so, consideration must be given to the microenvironment, which supports the growth and yield of the plant and translocation efficiency and conversion rate of the plant

Table 4: Effect of spacing and intercropping on yield indices of maize

Parameters	Treatments						
	SM100	SM50	MC100	MC50	MB100	MB50	SEM
Leaf/stem ratio	0.84^{ab}	0.79^{bc}	0.84^{ab}	0.90^{a}	0.73^{c}	0.82^{abc}	0.08
Ear weight/plant (g)	168.89^{c}	172.78^{bc}	225.56^{ab}	131.67^{c}	260.00^{a}	140.00^{c}	115.61
Husk weight/plant (g)	60.89^{b}	51.67^{bc}	78.45^{a}	35.06^{d}	78.61^{a}	41.22^{cd}	36.93
Cob weight/plant (g)	117.72^{bc}	111.5^{bc}	138.22^{ab}	84.45^{c}	173.39^{a}	90.11^{bc}	77.41
Husk/cob ratio	0.586^{ab}	0.473^{ab}	0.593^{a}	0.417^{b}	0.453^{ab}	0.463^{ab}	0.05
Dry/green leaf ratio	0.28^{c}	0.47^{b}	0.48^{b}	0.68^{a}	0.38^{b}	0.71^{a}	0.05
Herbage yield (KgDM/ha)	1154.30^{c}	2755.20^{a}	1891.40^{b}	2513.00^{a}	1995.53^{b}	2643.55^{a}	223.58

abcd: Means on the same row with different superscripts are significant (P<0.05)
SM100 =Sole maize at 100cm spacing; SM50 = Sole maize at 50cm spacing
MC100 =Maize/Akidi at 100cm spacing; MC50 = Maize/Akidi at 50cm spacing
MB100 =Maize/Bambara 100cm spacing; MB50 = Maize/Bambara 50cm spacing

Conclusion and recommendation

The results of this study have shown that plant spacing and intercropping maize with vegetable cowpea and Bambara nut had significant effects on maize growth and yield attributes. Intercropping maize with the legumes at 100cm x 100cm resulted in higher growth, ear and cob weights while the intercrops at closer spacing had higher leaf/stem ratios and herbage yield. Further studies should be carried out to determine the effect of the treatment imposed in this study on the growth and yield of the legumes and on the forage quality indices of the plants.

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Received: 10th November, 2017
Accepted: 21st February, 2018