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# Growth and Development of Late Season Maize/soybean Intercropping in Response to Nitrogen and Crop Arrangement in the Forest Agro-ecology of South Southern Nigeria

[1]U.L. Undie, [2]D.F. Uwah and [1]E.E. Attoe

[1]Department of Agronomy, Cross River University of Technology, Obubra Campus, Nigeria
[2]Department of Crop Science, University of Calabar, Nigeria

*Corresponding Author: U.L. Undie, Department of Agronomy, Cross River University of Technology, Obubra Campus, Nigeria*

## ABSTRACT

Intensive production of maize with legumes during early rains in the High Rainforest region of South Southern Nigeria is limited by heavy rainfall. Production of late season maize/legumes by peasant farmers is gaining prominence though yields are low due to low soil fertility and improper crop arrangement. The objective of this research was to investigate the performance of late season maize/soybean intercropping in response to nitrogen fertilization and spatial arrangement of the intercrops. The trial was a split-plot design in randomized complete block with three replications. Treatments consisted of five nitrogen rates (0, 25, 50, 75 and 100 k $ha^{-1}$), two sole crops and three maize/soybean intercrop arrangements (1:1, 2:2 and 1:2). Application of nitrogen positively influenced the two crops either as sole crops or as intercrops. Nitrogen increased plant height, number of leaves per plant and stem girth in both crops up to the 100 kg $ha^{-1}$. Similarly, the number of branches in soybean and LAI and stover yield in maize also responded up to the 100 kg $ha^{-1}$ used. Haulm yield in soybean responded optimally at 50 kg N $ha^{-1}$. Intercropping maize with soybean reduced maize plant height, LAI, stem girth, number of leaves per plant and stover yield below their sole crop values. Similarly, soybean stem girth, number of branches per plant and haulm yields were reduced below their sole crop values when intercropped with maize. Soybean plant height increased above its sole crop height at all intercrop arrangements. There were no significant interaction effects between nitrogen and crop arrangements. Growing maize and soybean in alternating single rows decreased stover and haulm yields much more than growing the two crops in alternating double rows or in one row of maize alternating with two rows of soybean.

**Key words:** Intercropping, additive mixture, maize, soybean, fertilizer, crop arrangement

## INTRODUCTION

Maize (*Zea mays* L.) is an important source of carbohydrate in human diet in the developing world and as animal feed worldwide (Onasanya *et al*., 2009). Expansion in the cultivation of early season maize crop in the humid Tropical Rainforest agro-ecology of South Southern Nigeria is limited by lack of appropriate technologies for preservation of the fresh harvest. Early season maize is planted in mixture with other crops and is harvested first from the mixture for subsistence or sold as fresh maize to urban dwellers. The large gap between demand and supply of maize produce has necessitated expansion of cultivation into the second cropping season. Soybean, *Glycine max* (L.)

Merrill (Leguminosae) is an important source of protein for man and animals globally (Singh, 2011). Despite its importance, soybean is not a common crop in the farming systems of the humid Southern Nigeria (Oko *et al*., 1991). This is due to heavy rainfall which predisposes the crop to rot when grown and harvested as early season crop. But soybean can successfully be cultivated in the Tropical Rain Forest during the late planting season to take advantage of the approaching dry harmatan winds in preserving the crop (Oko *et al*., 1991).

Subsistence farmers in the tropics rely on mixed cropping as their crop production system (Sivaraman and Palaniappan, 1996). Recent research findings have shown that mixed cropping shall continue to be more beneficial to these small scale farmers for obvious reasons. Mixed cropping provides security in food output which is considered more important than food maximization (Mortimore *et al*., 1997; Brintha and Seran, 2009). It also suppresses weeds (Bilalisa *et al.,* 2010), increases cash return to the farmers and provides higher yield advantages over sole cropping (Brintha and Seran, 2008; Seran and Brintha, 2010), The commonest food crops grown in this region are yams, cassava, maize, plantain and cocoyam. Three or more of these crops in combination are common on farmer's plots with rarely any legume in the combinations. . The cereal may also benefit from the nitrogen fixed in the root nodules of the legumes in the current year (Hauser, 1992; Chalk, 1996) or subsequent years (Mulongoy *et al*., 1992; Giller and Wilson, 1993).

Information on fertilizer requirements of late season cereal-legume mixtures in the humid South Southern Nigeria is scanty. The information gap may be due to contrasting fertilizer requirements of the component crops (Ennin *et al*., 2002) or to uneven fertilizer loss due to heavy rains during the first raining season which leaches much of the soluble soil nutrients (Kariaga, 2004). Available information is conflicting on the effects of increasing nitrogen availability on the productivity of legume-non legume intercropping. Midmore (1993) reported that addition of nitrogen fertilizer to intercrops raised yields of both components, but reduced the relative advantage of intercropping. Siame *et al*. (1998) observed that the yield components and yield of maize/*Phaseolus* intercrop responded significantly to nitrogen, up to the 120 kg N $ha^{-1}$ applied, in all the intercropping treatments. Chiezey *et al*. (2005) obtained significant increase in grain yield of sorghum grown as a component crop with soybean but the effect of nitrogen on soybean was not significant.

There is a clear indication from the above review that the cereal components must be fertilized for appreciable yield to be obtained. The response of the legume components of the intercrop, however, seems unpredictable.

Spatial arrangement of component crops in intercropping influences the use of resources available to the crops. There is potential for higher productivity of intercrops when mixtures are appropriately arranged to reduced inter-specific competition for limiting resources such as solar radiation (Keating and Carberry, 1993), nutrients (Dahmardeh *et al*., 2010) or water (Morris and Garrity, 1993). Maximization of resources use by crops in mixture will therefore, depend on the geometry and plant architecture of the component crops (Clark and Myers, 1994; Heitholt *et al*., 2005). In a mixture like maize and soybean, the taller maize is likely to use available sunlight more effectively to the detriment of the lower soybean. Chiezey *et al*. (2004) found that crop arrangement had no significant effect on the height of the taller sorghum. But soybean, on the same row with sorghum was taller (8.8%) than when planted on alternate rows with sorghum due to shading effect. Similarly, crop arrangement had no significant effect on leaf area index of sorghum but that of soybean significantly increased by 22.7% in alternate row arrangement. Similar observations have been reported for maize/bean (Silwana and Lucas, 2002), maize/cowpea (Dahmardeh *et al*.,

2010) and maize soybean intercropping (Ennin *et al.*, 2002). Higher system yield in additive intercropping is an indication that resources are maximized (Willey, 1990; Ennin *et al.*, 2002).

Soils of the Tropical Rain Forest are heavily leached of plant nutrients during the early rains (Aune and Lal, 1997). Sustainable production of maize on these soils requires investing heavily on fertilizers. Fertilizers, where available, are used sub-optimally and this accounts for the low productivity under subsistence farming. In traditional farming the crops in mixture are planted with no regard to proper arrangement for effective use of environmental resources. This research was, therefore, undertaken with the objective of evaluating the effects of nitrogen and crop arrangement on the growth and development of late season maize/soybean intercropping.

## MATERIALS AND METHODS

**Experimental site:** Field experiments were conducted in September to December of, 2007 and 2008 to study the effect of nitrogen application on yield and yield components of late season maize/soybean intercropping. The study was sited at the Teaching and Research Farm of the Cross River University of Technology, Akamkpa. Akamkpa (5°15"; 8°22" E) lies in the tropical rainforest agro-ecology of the Equatorial climatic belt of Nigeria. The mean annual temperature of the area ranges between 23 to 35°C with daily range of about 3°C. The area has distinct wet and dry seasons with mean annual rainfall ranging from 1,250 to 4,000 mm. The wet season has double rainfall peaks during July and October with a short break in rainfall called "August break" in between the double peaks. Consequently, there are two cropping seasons (early: from March to July and late: from August to December) in the area.

The soils of Akamkpa are formed from Basement complex, predominantly granite and gneiss, and are classified as dystic cambisol. The soils are fine, granular and sandy loam in texture and are well-drained (Ibanga *et al.*, 1989). The, 2007 experimental site was under cassava cultivation for five years but left fallow for one year, before the commencement of the experiment. The 2008 experimental site was under yam cultivation for one year and was fallowed for two years before the start of the experiment. The predominant weeds were *Chromolaena odorata* (L.) and *Mucuna* spp.

**Planting materials:** Hybrid maize (OBA SUPER 2) and soybean (TGX 1440-IE) cultivar were used for the experiment. OBA SUPER 2 is yellow coloured maize developed by Premier Seed, Nigeria Limited of Chikayi Industrial Estate, Zaria. The seeds were obtained from the National Seed Service, Umudike. The hybrid maize was selected on the basis of its high yield, adaptability to the climatic zone and its resistance to diseases, especially *Striga*, but the hybrid crop is yet to be widely accepted and grown with or as a replacement for the traditional white maize varieties in this agro-ecology. TGX 1440-IE is a cream coloured soybean cultivar of medium maturity (90-120 days). This high yield variety (Okpara and Ibiam, 2000) was obtained from Michael Okpara University of Agriculture, Umudike.

**Treatments, experimental design and plot size:** The experimental treatments consisted of five nitrogen levels (O, 25, 50, 75 and 100 kg N $ha^{-1}$) and five crop arrangements. The arrangements were sole maize, sole soybean and maize: soybean intercrop arrangements of 1:1, 2:2 and 1:2, respectively. The treatment combinations were assigned to a split plot design in a randomized complete block with three replications. The five rates of nitrogen were randomly assigned to the main plots while the five types of crop arrangements were randomly allocated to the subplots. The gross main plot size was 3 ×10 m (30 $m^2$), while the subplot size was 3 m×2 m (6 $m^2$). The net plot size for data collection was 1×1.5 m (1.5 $m^2$).

**Soil analysis:** Soil samples were randomly obtained with a soil auger from a depth of 0-30 cm prior to fertilization. The samples so collected were composited and analyzed in the Soil Science Laboratory of the Department of Soil Science, University of Calabar, Calabar. Particle size analysis was determined by the hydrometer method using sodium hexametaphosphate (Calgon) solution as outlined by Juo (1979). The textural class was determined by the use of standard textural triangle. Soil samples for chemical analysis were air dried and ground to pass through a 23 mm sieve for the subsequent procedures and analyses. Soil pH was measured with a glass electrode pH meter in soil water suspension of 1:2.5 and organic carbon was determined by the Walkley and Black wet oxidation methods as given in Juo (1979).Total soil nitrogen was determined by the macro-kjedahl method of Bremner (1965). Available P was determined by the method of Murphy and Riley (1962). Phosphorus was determined calorimetrically using molybdenum blue. Calcium and magnesium were estimated by the Versenate EDTA Titration method (Juo, 1979), while exchangeable K and Na were estimated by flame photometry (Juo, 1979). The exchangeable cations were determined on extracts obtained after leaching soil samples with neutral normal ammonium acetate solution (IITA, 1979).

**Meteorological data:** The temperature and rainfall data for 2007 and 2008 cropping years were obtained from the Nigeria Meteorological Services (NIMET), Margaret Ekpo International Airport, Calabar.

**Cultural practices:** The 2007 crops were planted on 22nd September, 2007 while the, 2008 crops were planted on 5th September, 2008. Three seeds of each crop were sown manually per hole using a meter tape to achieve the desired distances. The seedlings were thinned to one plant per stand at one week after sowing. Interplant spacing was maintained at 25 cm throughout for maize and 5 cm for soybean except in 1:2 arrangement where it was 10 cm. The crops were sown as sole maize (1:0) or sole soybean (0:1) and three arrangements of maize and soybean intercropping of 1 row maize to I row soybean (1:1), 2 rows maize to 2 rows soybean (2:2) and I row maize to 2 rows soybeans (1:2). Plots in a replication were separated from each other by 1.5 m path. An additive or superimposed model was used and plant density was kept constant on a total plot area basis set at the optimum for sole crops and kept the same in intercrops. Maize was planted at 53,333 plants $ha^{-1}$ and soybean at 266,666 plants $ha^{-1}$ by adjusting within row spacing of the intercrops.

Rows were spaced 75 cm apart in sole maize and in sole soybean plots. Intercropped maize was 75 cm from maize to maize and 37.5 cm from maize to soybean rows in 1:1 arrangement but 37.5 cm from maize to maize or maize to soybean in 2:2 arrangement. In 1:2 arrangement, intercropped maize was 75 cm from maize to maize but 25 cm from maize to soybean. Intercropped soybean rows were 75 cm from soybean to soybean and 37.5 cm from soybean to maize rows in 1:1 arrangement but 37.5 cm from soybean to soybean or soybean to maize in 2:2 arrangement. However, in 1:2 arrangement, intercropped soybean was 25 cm from soybean to soybean or soybean to maize.

Phosphorus as single superphosphate (7.8%P) and potassium as muriate of potash (49.8% K) were applied at the rates of 30 kg P $ha^{-1}$ and 50 kg K $ha^{-1}$. The two fertilizers were uniformly broadcast and harrowed into the soil before planting. Nitrogen was applied as urea (46% N) at the rates as per each treatment. Half of the required dosage was applied two weeks after sowing and the remaining half was applied six weeks after sowing, all by side placement along the rows. Weeds were controlled post emergence by manual weeding with hoe at 4 and 8 weeks after sowing.

The, 2007 crops were harvested on 15th December, 2007 (81 days after sowing) while the 2008 crops were harvested on 24th December, 2008 (110 days after sowing). In both years, harvesting was done manually when the maize and the soybean had reached physiological maturity. In, 2007 earlier harvesting was due to earlier cessation of rainfall and subsequent dry up of the maize crop.

**Collection of crop data and measurements:** Crop data were taken randomly from crops within the net plot measuring 1.5 $m^2$. Ten plants of maize and twenty soybean plants were taken per plot for crop attributes and for yield measurements and computations.

The data collected for maize include number of leaves per plant, plant height measured at 4, 6, 8 and 10 weeks after sowing, days to 50% tasselling and stover yield.

The leaf area was thus estimated using the formula below (Elings, 2000).

$$\text{Leaf area} = L \times B \times K$$

Where:

L = Mean length of the leaf (cm)
B = Mean breadth of the leaf (cm)
K = Constant = 0.75 for maize

The Leaf Area Index (LAI) was then estimated from leaf area as follows:

$$\text{LAI} = \frac{L \times B \times 0.75 \times \text{No of leaves perplant}}{\text{Areaoccupied by the plants}}$$

The data taken for soybean were number of leaves per plant and plant height both recorded at 4, 6, 8 and 10 weeks after sowing. The number of branches per plant was recorded at 6, 8 and 10 weeks after sowing and the number of days to 50% flowering and final dry haulm yield calculated.

**Statistical analysis:** All the data collected were subjected to statistical analysis appropriate to the split design plot in a randomized complete block using Windows Statistical Package for Social Sciences (SPSS), Version 14. Analyses of variance (ANOVA) were constructed to examine nitrogen effect and its interaction on the variables measured. Treatment means were separated and compared using Duncan's Multiple Range Test (DMRT) at 5% probability level (Gomez and Gomez, 1984).

## RESULTS

**The physicochemical properties of the experimental site:** Results of the physical and chemical properties of the experimental sites are presented in Table 1. The results showed that the two sites were sandy loam in texture. However, the site for, 2007 experiment was lower in total nitrogen (0.09%) compared to the, 2008 site (0.13%). Generally, the, 2007 site was lower in all the nutrient elements measured, as well as in base saturation. The soil acidity was, however, higher in, 2007 site compared to, 2008 site. The average monthly minimum and maximum temperatures

Table 1: Physical and chemical properties of the soils of the experimental sites in 2007 and 2008 late planting season at Akamkpa South Southern Nigeria

| Properties | 2007 | 2008 |
|---|---|---|
| Physical composition (g kg$^{-1}$) | | |
| Sand | 10.0 | 5.0 |
| Silt | 13.0 | 19.7 |
| Clay | 77.0 | 75.3 |
| Textural class | Sandy loam | Sandy loam |
| **Chemical characteristics** | | |
| pH ($H_2O$) | 4.2 | 5.1 |
| Organic carbon (g kg$^{-1}$) | 1.13 | 1.63 |
| Total Nitrogen (g kg$^{-1}$) | 0.09 | 0.13 |
| Available Phosphorous (g kg$^{-1}$) | 2.75 | 3.12 |
| **Exchangeable bases (cmol kg$^{-1}$)** | | |
| Ca | 0.6 | 2.2 |
| Mg | 0.2 | 1.0 |
| K | 0.07 | 0.08 |
| Na | 0.04 | 0.05 |
| Exchangeable acidity (cmol kg$^{-1}$) | 4.8 | 3.0 |
| ECEC (cmol kg$^{-1}$) | 5.71 | 6.33 |
| Base Saturation (g kg$^{-1}$) | 16.0 | 53 |

Table 2: Temperature and rainfall data at Akamkpa during experiment in 2007 and 2008

| | Mean Temperature (°C) | | | | | |
|---|---|---|---|---|---|---|
| | 2007 | | 2008 | | Rainfall (mm) | |
| Month | Max | Min | Max | Min | 2007 | 2008 |
| August | 23.3 | 28.1 | 23.3 | 28.4 | 415.5 | 509.2 |
| September | 23.7 | 28.7 | 23.4 | 29.7 | 561.7 | 122.5 |
| October | 23.0 | 29.0 | 23.0 | 30.5 | 297.9 | 315.0 |
| November | 23.0 | 30.4 | 23.7 | 31.6 | 263.2 | 102.5 |
| December | 23.5 | 30.5 | 23.4 | 31.6 | 033.1 | 077.1 |

Source: Nigeria meteorological services (NIMET), calabar

of the agro-ecology of the experimental site are presented in Table 2. There was little variation in temperature between the months in either, 2007 or, 2008. The sowing month of September in both the years was warmer than the previous month. The highest temperatures occurred in December in both the years which were ideal for ripening and harvesting of the crops. The average monthly rainfall showed marked variation in each of the years (Table 2). In, 200 the average rainfall during planting in September was higher compared to that in, 2008. The average rainfall during harvest (December) in, 2007 on the other hand was lower compared to that in, 2008. Treatment effects of the two crops are presented below. Due to non significant interaction between nitrogen and crop arrangements, all the nitrogen results were averaged over crop arrangement.

**Plant height:** Application of nitrogen up to 100 kg ha$^{-1}$ significantly raised plant height of maize at al l sampling dates in both, 2007 and 2008 over when no nitrogen was used (Table 3). At 10 WAS, maize plant height increased by 78.9 cm in, 2007 and 36.8 cm in, 2008 over when no nitrogen was applied. Intercropping and crop arrangement had no significant effect on plant height

Table 3: Effects of nitrogen, intercropping and crop arrangement on plant height of maize at four sampling intervals in 2007 and 2008

| | Plant height (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 WAS | | 6 WAS | | 8 WAS | | 10WAS | |
| Nitrogen (N) (kg hg$^{-1}$) | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 |
| 0 | 41.2$^{e}$ | 50.9$^{d}$ | 51.8$^{e}$ | 86.0$^{e}$ | 69.9$^{d}$ | 155.2$^{e}$ | 98.9$^{e}$ | 156.0$^{e}$ |
| 25 | 50.8$^{d}$ | 53.2$^{d}$ | 60.7$^{d}$ | 96.9$^{d}$ | 100.2$^{c}$ | 162.6$^{d}$ | 135.3$^{d}$ | 164.9$^{d}$ |
| 50 | 52.8$^{c}$ | 56.2$^{c}$ | 74.3$^{c}$ | 107.0$^{c}$ | 119.6$^{b}$ | 169.0 $^{c}$ | 148.7$^{c}$ | 176.7$^{c}$ |
| 75 | 57.9$^{b}$ | 60.4$^{b}$ | 98.9$^{b}$ | 119.0$^{b}$ | 175.1$^{a}$ | 180.6$^{b}$ | 161.3$^{b}$ | 185.8$^{b}$ |
| 100 | 60.5$^{a}$ | 63.5$^{a}$ | 117.9$^{a}$ | 139.1$^{a}$ | 179.6$^{a}$ | 193.6$^{a}$ | 177.8$^{a}$ | 192.8$^{a}$ |
| SE± | 0.89 | 1.34 | 1.46 | 1.58 | 3.05 | 2.33 | 2.02 | 3.31 |
| **Crop arrangement (A)**$^{t}$ | | | | | | | | |
| 1:0 | 53.0$^{a}$ | 59.7$^{a}$ | 80.4$^{a}$ | 114.3$^{a}$ | 128.0$^{a}$ | 181.1$^{a}$ | 144.1$^{a}$ | 181.1$^{a}$ |
| 1:1 | 52.3$^{a}$ | 57.1a$^{b}$ | 79.8$^{a}$ | 110.6$^{b}$ | 127.4$^{a}$ | 172.5$^{b}$ | 143.6$^{a}$ | 176.5$^{ab}$ |
| 2:2 | 52.6$^{a}$ | 56.1a$^{b}$ | 81.7$^{a}$ | 106.0$^{c}$ | 129.3$^{a}$ | 167.6$^{c}$ | 144.3$^{a}$ | 172.5$^{b}$ |
| 1 1:2 | 52.7$^{a}$ | 54.5$^{b}$ | 81.0$^{a}$ | 107.6$^{c}$ | 130.9$^{a}$ | 167.6$^{c}$ | 145.6$^{a}$ | 170.8$^{b}$ |
| SE+ | 00.09 | 01.28 | 00.42 | 01.42 | 02.12 | 02.08 | 02.42 | 02.76 |
| N x A | ns | ns | ns | ns | ns | ns | ns | ns |

NS: Not significant. WAS: Weeks after sowing. $^{t}$Maize: Soybean. Means followed by a common letter in a column are not significantly different at 5% level

of maize at all the sampling intervals in, 2007 while in, 2008 intercropping and crop arrangement significantly influenced plant height at all the sampling periods (Table 3). In, 2008 plant height of sole maize at 4 WAS was statistically similar to plant height of 1:1 and 2:2 arrangements. In, 2008 plant height difference between the sole maize and 1:1 crop arrangement at 10 WAS was statistically the same but significantly higher than those at 2:2 or 1:2 arrangements.

In soybean, nitrogen significantly influenced plant height at all the sampling intervals in each of the years (Table 4). Thus, at 10 WAS, nitrogen application raised soybean plant height by 20 cm in 2007 and 19 cm in 2008, over when no nitrogen was applied. Similar trends were observed at all other sampling intervals in both the years.

Similarly, crop arrangement significantly affected plant height of soybean at some but not all the sampling intervals in both years (Table 4). At 4 WAS in both years, the sole soybean was taller than any of the intercrops. At all other intervals, the trend was reversed and the sole soybean became shorter than any of the intercrops.

**Number of leaves per plant:** The number of leaves per plant in maize was significantly increased at 100 kg N ha$^{-1}$ over when no nitrogen was applied at all the sampling intervals in both, 2007 and 2008 (Table 5). At this nitrogen level, the number of leaves at 12 WAS increased by 0.68 and 2.84 in 2007 and 2008, respectively, over no nitrogen application. The optimum number of leaves was obtained at 8 WAS at all the nitrogen rates used.

The effects of intercropping and crop arrangement on number of leaves in maize at four sampling intervals in, 2007 and 2008 are presented in Table 5. The result showed that the sole maize consistently produced the highest number of leaves than any of the intercrop arrangements at all the intervals in both the years. There were no statistical differences in the number of leaves amongst the different crop arrangements either in, 2007 or, 2008.

Table 4: Effects of nitrogen, intercropping and crop arrangement on plant height of soybean at four sampling periods in 2007 and 2008

| | Plant height (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 WAS | | 6 WAS | | 8 WAS | | 10 WAS | |
| Nitrogen (N) (kg ha$^{-1}$) | 2008 | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 | 2007 |
| 0 | 28.9$^{e}$ | 29.3$^{e}$ | 37.4$^{e}$ | 38.6$^{e}$ | 51.7$^{e}$ | 56.4$^{d}$ | 52.6$^{e}$ | 59.2$^{d}$ |
| 25 | 31.8$^{d}$ | 33.2$^{d}$ | 40.7$^{d}$ | 42.0$^{d}$ | 54.7$^{d}$ | 62.0$^{c}$ | 56.2$^{d}$ | 66.7$^{c}$ |
| 50 | 34.5$^{c}$ | 36.0$^{c}$ | 43.0$^{c}$ | 44.3$^{c}$ | 64.2$^{c}$ | 66.9$^{b}$ | 64.7$^{c}$ | 72.5$^{b}$ |
| 75 | 36.0$^{b}$ | 37.3$^{b}$ | 45.9$^{b}$ | 46.2$^{b}$ | 66.2$^{b}$ | 68.6$^{b}$ | 67.6$^{b}$ | 73.6$^{b}$ |
| 100 | 37.4$^{a}$ | 38.0$^{a}$ | 47.1$^{a}$ | 47.6$^{a}$ | 72.0$^{a}$ | 76.0$^{a}$ | 72.6$^{a}$ | 78.2$^{a}$ |
| SE± | 0.37 | 0.38 | 0.41 | 0.39 | 0.72 | 2.00 | 0.87 | 1.40 |
| **Crop arrangement (A)$^{t}$** | | | | | | | | |
| 0:1 | 34.2$^{a}$ | 35.3$^{a}$ | 41.0$^{c}$ | 41.9$^{c}$ | 56.5$^{c}$ | 57.8$^{c}$ | 57.6$^{d}$ | 62.0$^{c}$ |
| 1:1 | 33.3$^{c}$ | 34.5$^{bc}$ | 42.8$^{b}$ | 43.4$^{b}$ | 61.6$^{b}$ | 65.6$^{b}$ | 61.4$^{c}$ | 69.5$^{b}$ |
| 2:2 | 33.9$^{a}$ | 35.0$^{ab}$ | 43.0$^{b}$ | 43.7$^{b}$ | 62.6$^{b}$ | 67.9$^{b}$ | 64.0$^{b}$ | 71.2$^{b}$ |
| 1:2 | 33.5$^{b}$ | 34.0$^{c}$ | 44.6$^{a}$ | 46.0$^{a}$ | 66.3$^{a}$ | 72.8$^{a}$ | 68.0$^{a}$ | 76.7$^{a}$ |
| SE± | 0.33 | 0.32 | 0.37 | 0.35 | 0.64 | 1.80 | 0.78 | 1.30 |
| N×A | ns | ns | ns | ns | ns | ns | ns | ns |

NS: Not significant. WAS: Week after sowing. $^{t}$Maize: soybean. Means in a column followed by a common letter are not significantly different at 5% level

Table 5: Effects of nitrogen, intercropping and crop arrangement on number of leaves per plant of maize at four sampling intervals in 2007 and 2008

| | Number of leaves per plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 WAS | | 6 WAS | | 8 WAS | | 10 WAS | |
| Nitrogen (N) (kg hg$^{-1}$) | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 |
| 0 | 6.54$^{e}$ | 6.85$^{d}$ | 9.07$^{d}$ | 9.32$^{b}$ | 12.60$^{d}$ | 12.28$^{c}$ | 11.52$^{c}$ | 10.92$^{c}$ |
| 25 | 7.28$^{d}$ | 7.17$^{c}$ | 9.68$^{c}$ | 9.42$^{b}$ | 12.92$^{c}$ | 12.68$^{b}$ | 11.58$^{c}$ | 11.83$^{b}$ |
| 50 | 8.00$^{c}$ | 7.98$^{c}$ | 9.84$^{c}$ | 9.75$^{b}$ | 13.12$^{b}$ | 13.28$^{ab}$ | 11.73$^{bc}$ | 13.04$^{a}$ |
| 75 | 8.20$^{b}$ | 8.19$^{b}$ | 10.19$^{b}$ | 10.46$^{a}$ | 13.19b | 13.60$^{ab}$ | 12.02$^{ab}$ | 13.46$^{a}$ |
| 100 | 8.66$^{a}$ | 8.76$^{a}$ | 10.82$^{a}$ | 10.96$^{a}$ | 13.53$^{a}$ | 13.68$^{a}$ | 12.20$^{a}$ | 13.76$^{a}$ |
| SE± | 0.06 | 0.12 | 0.12 | 0.28 | 0.10 | 0.47 | 0.20 | 0.36 |
| **Crop arrangement (A)$^{t}$** | | | | | | | | |
| 1:0 | 7.84$^{a}$ | 7.99$^{a}$ | 9.98$^{a}$ | 10.47$^{a}$ | 13.36$^{a}$ | 13.67$^{a}$ | 12.22$^{a}$ | 12.97$^{a}$ |
| 1:1 | 7.46$^{b}$ | 7.67$^{a}$ | 9.82$^{a}$ | 9.88$^{b}$ | 13.05$^{a}$ | 13.36$^{ab}$ | 11.54$^{b}$ | 12.75$^{ab}$ |
| 2:2 | 7.81$^{a}$ | 7.74$^{a}$ | 9.95$^{a}$ | 9.70$^{b}$ | 13.03$^{a}$ | 12.75$^{ab}$ | 11.88$^{ab}$ | 12.73b |
| 1:2 | 7.83$^{a}$ | 7.74$^{a}$ | 9.95$^{a}$ | 9.88$^{b}$ | 13.05$^{a}$ | 12.66$^{b}$ | 11.58$^{b}$ | 12.25$^{b}$ |
| SE± | 0.05 | 0.13 | 0.16 | 0.20 | 0.09 | 0.40 | 0.68 | 0.32 |
| **Interaction** | | | | | | | | |
| N×A | ns | ns | ns | ns | ns | ns | ns | ns |

NS: Not significant. WAS: Weeks after sowing. $^{t}$Maize: soybean. Means followed by a common letter in a column are not significantly different at 5% level

The effect of nitrogen on number of leaves per plant in soybean was significant at each of the sampling intervals in each of the years (Table 6). At 4 and 6 WAS in each year, the number of leaves in soybean significantly increased at all nitrogen rates from 0 to 100 kg ha$^{-1}$. From 8 to 12 WAS in each year, the optimum number of leaves were obtained at 50 kg N ha$^{-1}$. At 100 kg N ha$^{-1}$, the number of leaves at 8 to 12 WAS dropped below those obtained at 50 kg N ha$^{-1}$.

Table 6: Effect of nitrogen, intercropping and crop arrangement on number of leaves per plant of soybean in 2007 and 2008

| | Number of leaves per plant | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 WAS | | 6 WAS | | 8 WAS | | 10 WAS | | 12 WAS | |
| Nitrogen (N) (kg ha$^{-1}$) | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 |
| 0 | 8.7$^{e}$ | 9.1$^{e}$ | 21.4$^{e}$ | 21.4$^{e}$ | 39.1$^{d}$ | 41.4$^{d}$ | 52.2$^{c}$ | 52.9$^{b}$ | 43.3$^{d}$ | 44.7$^{b}$ |
| 25 | 9.1$^{d}$ | 9.7$^{d}$ | 23.3$^{d}$ | 24.3$^{d}$ | 54.3$^{c}$ | 48.5$^{c}$ | 59.9$^{b}$ | 53.5$^{b}$ | 49.8$^{c}$ | 48.9$^{a}$ |
| 50 | 10.2$^{c}$ | 10.3$^{c}$ | 26.6$^{c}$ | 24.7$^{c}$ | 63.3$^{a}$ | 50.5$^{a}$ | 70.4$^{a}$ | 64.6$^{a}$ | 60.2$^{a}$ | 51.1$^{a}$ |
| 75 | 10.6$^{b}$ | 68.2$^{a}$ | 61.7$^{a}$ | 54.8$^{a}$ | 49.0 | 10.5$^{b}$ | 28.6$^{b}$ | 25.9$^{b}$ | 60.4$^{b}$ | 49.4$^{b}$ |
| 100 | 11.1$^{a}$ | 11.0$^{a}$ | 29.2$^{a}$ | 26.7$^{a}$ | 54.2$^{c}$ | 41.3$^{d}$ | 69.6$^{b}$ | 62.2$^{a}$ | 55.2$^{b}$ | 50.9$^{a}$ |
| SE± | 0.11 | 0.11 | 00.29 | 00.21 | 0.81 | 1.10 | 1.05 | 1.45 | 0.91 | 1.06 |
| **Crop arrangement (A)$^{t}$** | | | | | | | | | | |
| 0:1 | 10.2$^{a}$ | 10.4$^{a}$ | 27.1$^{a}$ | 25.8$^{a}$ | 58.9$^{a}$ | 57.2$^{a}$ | 74.0$^{a}$ | 76.9$^{a}$ | 65.1$^{a}$ | 64.8$^{a}$ |
| 1:1 | 09.7$^{c}$ | 10.4$^{a}$ | 25.1$^{c}$ | 22.8$^{c}$ | 49.2$^{c}$ | 39.6$^{c}$ | 57.7$^{c}$ | 50.6$^{c}$ | 44.2$^{c}$ | 36.4$^{c}$ |
| 2:2 | 10.0$^{ab}$ | 10.2$^{b}$ | 26.3$^{b}$ | 24.4$^{b}$ | 54.6$^{b}$ | 45.2$^{c}$ | 62.1$^{b}$ | 55.6$^{b}$ | 50.4$^{b}$ | 48.1$^{b}$ |
| 1:2 | 09.9$^{b}$ | 10.1$^{b}$ | 26.3$^{b}$ | 24.4$^{b}$ | 54.6$^{b}$ | 42.7$^{b}$ | 61.8$^{b}$ | 52.8$^{b}$ | 50.8c | 46.4b |
| SE± | 0.10 | 0.10 | 0.21 | 0.18 | 0.72 | 0.94 | 0.94 | 1.29 | 0.81 | 0.95 |
| N×A | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns |

NS: Not significant. WAS: Week after sowing, [t]Maize: Soybean Means in a column followed by a common letter are not significantly different at 5% level

In soybean, intercropping and crop arrangement significantly affected the number of leaves at all the sampling intervals in each of the years (Table 6). At 4 WAS in, 2007 and 6, 8, 10 and 12 WAS in both years, the sole crop produced significantly higher number of leaves per plant than either 1:1, 1:2 or 2:2 intercrop arrangements, while the 1:1 arrangement produced significantly the lowest.

**Leaf area index (LAI):** Application of nitrogen to maize had significant effect on its LAI at all the sampling periods in, 2007 and 2008 (Table 7). At 10 WAS, the 100 kg N ha$^{-1}$ increased the maize LAI by 1.18 cm in, 2007 and 1.45 cm in, 2008 over the indices obtained when no nitrogen was applied.

Among the different crop arrangements, the LAI were statistically similar at all sampling intervals except at 10 WAS where the LAI of 1:1 and 2:2 arrangements were statistically higher than that obtained at 1:1 arrangement.

**Stem girth:** In both, 2007 and 2008 nitrogen rates from 0 to 100 kg ha$^{-1}$ significantly increased the stem girth of maize at each of the applied rate except the girths at 50 and 75 kg N ha$^{-1}$ in, 2008 which were statistically the same (Table 8). The 100 kg N ha$^{-1}$ increased maize stem girth by 0.85 cm in, 2007 and 0.97 cm in, 2008 over when no nitrogen was applied. In soybean, application of nitrogen up to 100 kg ha$^{-1}$ significantly increased its stem girth at all the applied levels in both, 2007 and 2008 (Table 8). Application of 100 kg N ha$^{-1}$ raised soybean stem girth by 0.26 cm in, 2007 and 0.27 cm in, 2008. In both maize and soybean and in both years, the sole crops produced the biggest stem girths than any of the intercrop arrangements, while among the intercrop arrangements, the 1:1 arrangement produced the smallest girths (Table 8). Stem girths at 2:2 and 1:2 arrangements were statistically similar. Number of branches per plant Nitrogen significantly influenced number of branches per plant in soybean at all the sampling intervals in, 2007 and 2008 (Table 9). At 10 WAS, the optimum number of branches were obtained 75 kg N ha$^{-1}$ in both the years. Intercropping and crop arrangement significantly influenced number of branches per

Table 7: Effects of nitrogen, intercropping and crop arrangement on leaf area index of soybean in 2007 and 2008

| | Leaf area index | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 WAS | | 6 WAS | | 8 WAS | | 10 WAS | |
| Nitrogen (N) kg ha$^{-1}$ | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 |
| 0 | 0.77$^e$ | 0.98$^e$ | 1.47$^e$ | 1.81$^e$ | 1.78$^e$ | 2.09$^e$ | 1.92$^e$ | 2.20$^e$ |
| 25 | 0.84$^d$ | 1.24$^d$ | 1.66$^d$ | 1.96$^d$ | 2.12$^d$ | 2.52$^d$ | 2.15$^d$ | 2.58$^d$ |
| 50 | 1.14$^c$ | 1.47$^c$ | 2.01$^c$ | 2.25$^c$ | 2.51$^c$ | 2.81$^c$ | 2.56$^c$ | 2.83$^c$ |
| 75 | 1.31$^b$ | 1.65$^b$ | 2.14$^b$ | 2.63b | 2.74$^b$ | 3.17$^b$ | 2.77b | 3.25$^b$ |
| 100 | 1.51$^a$ | 1.86$^a$ | 2.47$^a$ | 2.91$^a$ | 2.98$^a$ | 3.60$^a$ | 3.10$^a$ | 3.65$^a$ |
| SE± | 0.059 | 0.016 | 0.129 | 0.06 | 0.1 | 0.065 | 0.204 | 0.051 |
| **Arrangement (A)$^t$** | | | | | | | | |
| 1:00 | 1.15$^a$ | 1.47$^a$ | 2.03$^a$ | 2.32$^a$ | 2.49$^a$ | 2.96$^a$ | 2.62$^a$ | 2.98$^a$ |
| 1:01 | 1.10$^b$ | 1.43$^b$ | 1.91$^b$ | 2.29a | 2.37$^b$ | 2.77$^b$ | 2.45$^b$ | 2.81$^b$ |
| 2:02 | 1.09$^b$ | 1.43$^b$ | 1.92$^b$ | 2.32a | 2.42$^{ab}$ | 2.82$^b$ | 2.47$^b$ | 2.92$^a$ |
| 1:02 | 1.11$^b$ | 1.44$^b$ | 1.94$^b$ | 2.33a | 2.43$^{ab}$ | 2.81$^b$ | 2.47$^b$ | 2. 90$^a$ |
| SE+ | 0.015 | 0.014 | 0.028 | 0.053 | 0.043 | 0.058 | 0.044 | 0.045 |
| **N×A** | ns | | ns | | ns | | ns | ns |

Ns: Not significant, WAS: Weeks after sowing, T: Maize soybean, Means followed by a common letter in a column are not significantly different at 5% level

Table 8: Effects of nitrogen, intercropping and crop arrangement on mean stem girths of maize and soybean in 2007 and 2008

| | Maize stem girth (cm) | | Soybean stem girth (cm) | |
|---|---|---|---|---|
| Nitrogen (N) (kg ha$^{-1}$) | 2007 | 2008 | 2007 | 2008 |
| 0 | 1.12$^e$ | 1.27$^d$ | 0.08$^e$ | 0.08$^c$ |
| 25 | 1.24$^d$ | 1.52$^c$ | 0.14$^d$ | 0.15$^d$ |
| 50 | 1.52$^c$ | 1.81$^b$ | 0.18$^c$ | 0.18$^c$ |
| 75 | 1.72$^b$ | 1.87$^b$ | 0.24$^b$ | 0.27$^b$ |
| 100 | 1.97$^a$ | 2.24$^a$ | 0.34$^a$ | 0.35$^a$ |
| SE± | 0.03 | 0.05 | 0.005 | 0.013 |
| **Crop arrangement (A)$^t$** | | | | |
| 1:00 | 1.59$^a$ | 1.81$^a$ | 0.23$^a$ | 0.24$^a$ |
| 1:01 | 1.42$^c$ | 1.62$^c$ | 0.16$^c$ | 0.78$^c$ |
| 2:02 | 1.51$^b$ | 1.76$^b$ | 0.19$^b$ | 0.20$^b$ |
| 1:02 | 1.53$^b$ | 1.77$^b$ | 0.20$^b$ | 0.20$^b$ |
| SE± | 0.03 | 0.04 | 0.005 | 0.008 |
| **N×A** | ns | ns | ns | ns |

Ns: Not significant, WAS: Weeks after sowing, T: Maize soybean, Means followed by a common letter in a column are not significantly different at 5% level

plant at all the sampling intervals in both years (Table 9). At each of the intervals in both years, the sole crop consistently and significantly produced the highest number of branches per plant than any of the intercrop arrangement. Among the intercrops, the 1:1 crop arrangement significantly produced the lowest number of branches while the number of branches at 1:2 and 2:2 crop arrangements were statistically the same. Number of days to 50% tasselling/flowering: Increasing nitrogen rates from 0 to 100 kg ha$^{-1}$ significantly decreased the number of days to 50% tasselling in maize by 5.3 and 4.4 days in, 2007 and 2008, respectively (Table 10). Number of days to 50%

Table 9: Effects of nitrogen and crop arrangement on mean number of branches per plant of soybean at three sampling periods in 2007 and 2008

| | Number of branches/plant | | | | | |
|---|---|---|---|---|---|---|
| | 6 WAS | | 8 WAS | | 10 WAS | |
| Nitrogen (N) (kg ha$^{-1}$) | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 |
| 0 | 1.43$^{d}$ | 1.56$^{d}$ | 2.13$^{d}$ | 2.17$^{c}$ | 2.01$^{d}$ | 2.27$^{c}$ |
| 25 | 1.67$^{c}$ | 1.91$^{c}$ | 2.47$^{bc}$ | 2.41$^{b}$ | 2.51$^{bc}$ | 2.46$^{b}$ |
| 50 | 2.05$^{a}$ | 2.18$^{a}$ | 2.58$^{ab}$ | 2.54$^{b}$ | 2.63$^{ab}$ | 2.52$^{b}$ |
| 75 | 1.96$^{ab}$ | 2.14$^{ab}$ | 2.78$^{a}$ | 2.80$^{a}$ | 2.80$^{a}$ | 2.86$^{a}$ |
| 100 | 1.86$^{b}$ | 2.02$^{bc}$ | 2.33$^{cd}$ | 2.49$^{b}$ | 2.37$^{c}$ | 2.61$^{b}$ |
| SE± | 0.081 | 0.068 | 0.103 | 0.097 | 0.094 | 0.084 |
| **Crop arrangement (A)$^{t}$** | | | | | | |
| 0:01 | 2.43$^{a}$ | 2.77$^{a}$ | 3.30$^{a}$ | 3.53$^{a}$ | 3.27$^{a}$ | 3.62$^{a}$ |
| 1:01 | 1.31$^{c}$ | 1.45$^{c}$ | 1.85$^{c}$ | 1.89$^{c}$ | 1.91$^{c}$ | 1.98$^{c}$ |
| 2:02 | 1.70$^{b}$ | 1.77$^{b}$ | 2.36$^{b}$ | 2.29$^{b}$ | 2.31$^{b}$ | 2.21$^{b}$ |
| 1:02 | 1.74$^{b}$ | 1.85$^{b}$ | 2.32$^{b}$ | 2.21$^{b}$ | 2.37$^{b}$ | 2.21$^{b}$ |
| SE± | 0.072 | 0.061 | 0.092 | 0.087 | 0.084 | 0.075 |
| **N×A** | ns | ns | ns | ns | ns | ns |

ns: Not significant. WAS: Week after sowing. [t]Maize: soybean. Means in a column followed by a common letter are not significantly different at 5% level

Table 10: Effects of nitrogen, intercropping and crop arrangement on mean number of days to 50 percent tasselling of maize and 50% flowering of soybean in 2007 and 2008

| | Days to 50% tasselling | | Days to 50% flowering | |
|---|---|---|---|---|
| Nitrogen (A) (kg ha$^{-1}$) | 2008 | 2007 | 2008 | 2007 |
| 0 | 55.5$^{a}$ | 53.7$^{a}$ | 50.2$^{e}$ | 50.4$^{e}$ |
| 25 | 54.5$^{b}$ | 53.1$^{b}$ | 50.8$^{b}$ | 51.8$^{d}$ |
| 50 | 53.5$^{c}$ | 52.5$^{c}$ | 52.1$^{c}$ | 52.4$^{c}$ |
| 75 | 52.8$^{d}$ | 50.7$^{d}$ | 53.1$^{b}$ | 53.8$^{b}$ |
| 100 | 50.2$^{e}$ | 49.3$^{e}$ | 54.5$^{a}$ | 55.2$^{a}$ |
| SE± | 0.26 | 0.25 | 0.26 | 0.33 |
| **Crop arrangement (A)$^{t}$** | | | | |
| 1:0 | 53.1$^{a}$ | 51.9$^{a}$ | 52.3$^{a}$ | 52.7$^{a}$ |
| 1:1 | 53.7$^{a}$ | 52.0$^{a}$ | 51.9$^{a}$ | 52.9$^{a}$ |
| 2:2 | 53.2$^{a}$ | 51.8$^{a}$ | 52.1$^{a}$ | 52.5$^{a}$ |
| 1:2 | 53.2$^{a}$ | 51.6$^{a}$ | 52.2$^{a}$ | 52.6$^{a}$ |
| SE± | 0.23 | 0.22 | 0.23 | 0.29 |
| N×A | ns | ns | ns | ns |

ns: Not significant. WAS: Weeks after sowing. [t]Maize: Soybean. Means followed by a common letter in a column are not significantly different at 5% level

flowering in soybean was increased by 4.3 and 4.8 days in, 2007 and 2008, respectively (Table 10). Intercropping and crop arrangement had no significant effect on number of days to 50% tasselling in maize or 50% flowering in soybean either in, 2007 or, 2008 (Table 10).

**Stover and haulm yield:** In maize, application of nitrogen increased stover yield at all levels from 0 to 100 kg ha$^{-1}$ both in, 2007 and 2008 (Table 11). In soybean, haulm yield increased up to

Table 11: Effects of nitrogen, intercropping and crop arrangement on stover and haulm yield of maize and soybean in 2007 and 2008

| | Stover yield (kg ha$^{-1}$) | | Haulm yield (kg ha$^{-1}$) | |
|---|---|---|---|---|
| Nitrogen (N) kg ha$^{-1}$ | 2007 | 2008 | 2007 | 2008 |
| 0 | 825.3$^d$ | 1191.8$^e$ | 180.6$^c$ | 913.5$^e$ |
| 25 | 935.8$^c$ | 1335.6$^d$ | 199.1$^b$ | 1135.2$^c$ |
| 50 | 1016.5$^b$ | 1501.9$^c$ | 240.7$^a$ | 1350.8$^a$ |
| 75 | 1068.1$^b$ | 1736.1$^b$ | 208.1$^b$ | 1203.4$^b$ |
| 100 | 1157.6$^a$ | 1886.2$^a$ | 171.3$^c$ | 1037.6$^d$ |
| SE± | 0021.4 | 0035.4 | 3.89 | 24.1 |
| **Crop Arrangement (A)** | | | | |
| 1:0 | 1012.7$^a$ | 1342.3$^a$ | 279.3$^a$ | 1533.7$^a$ |
| 1:1 | 876.9$^c$ | 1057.4$^c$ | 190.9$^c$ | 1162.2$^c$ |
| 2:2 | 942.6$^b$ | 1168.9$^b$ | 236.4$^b$ | 1321.8$^b$ |
| 1:2 | 897.2$^b$ | 1153.3$^b$ | 241.6$^b$ | 1284.3$^b$ |
| SE± | 009.32 | 0014.81 | 003.21 | 0026.7 |
| N×A | ns | ns | ns | ns |

NS = not significant. WAS: weeks after sowing. Means followed by a common letter in a column are not significantly different at 5 percent level

50 kg ha$^{-1}$, in both years, beyond which there was a decline in yield (Table 11). The yield levels at 75 kg N ha$^{-1}$ were similar to those at 25 kg N ha$^{-1}$ but lower at 100 kg N ha$^{-1}$. Intercropping decreased stover yield in maize and haulm yield in soybean, at each of the intercrop arrangements, compare to the sole crops in both, 2007 and 2008 (Table 11). Among the intercrop arrangements, the 1:1 arrangement produced the lowest yield both in maize and soybean while the yield difference between 2:2 and 1:2 arrangements were statistically the same in both years.

## DISCUSSION

The positive and linear response in plant height, number of leaves per plant, leaf area index and stover yield in maize to nitrogen was expected and this response confirmed the essentiality of nitrogen for plant growth and development, especially in cereals, as reported by Alabi *et al.* (2003) and Havlin (2007). The increase in vegetative parameters of plant height, number of leaves per plant, leaf area index, stem girth and number of branches per plant in maize, sorghum or pearl millet as sole crops or intercrops with application of nitrogen have been reported by other workers (Chiezey *et al.*, 1992; Clark and Myers, 1994; Olasantan *et al.*, 1996; Clement *et al.*, 1992; Siame *et al.*, 1998; Scharf *et al.*, 2002; Chiezey *et al.*, 2004; Silwana *et al.*, 2007). The decreased number of leaves in both maize and soybean and leaf area index in maize above 50 kg N ha$^{-1}$ at 8 to 10 weeks after sowing as observed in this study might be due to increased vegetative growth in both the crops, more especially in the taller maize, which caused intra-specific and inter-specific shading. The shading effect might have, consequently caused death, senescence and dropping of the lower leaves of the intercrops. A similar observation was made by Silwana *et al.* (2007) on bean cultivar "MAJUBA" when intercropped with maize at higher levels of nitrogen which they attributed to mutual shading by the component crops.

The decreased number of days to 50% tasselling in maize and the increased number of days to 50% flowering in soybean was consistent with the report by Chiezey *et al.* (2004) but contrasted with reports by Ologunde and Ogundela (1985) who obtained increased number of days to tasselling in maize with application of nitrogen. Havlin (2007) reported that adequate supply of nitrogen in conjunction with other inputs was associated with high photosynthetic activities, vigorous growth and consequently, early tasselling, anthesis and maturity in cereals like maize. The reduction in number of days to tasselling as observed in this study might, therefore, be due to the use of adequate amount of nitrogen and appropriate technologies. Balko and Russell (1980) and Lafitte and Edmeades (1995) reported that when cereals were subjected to various stresses such as drought and nitrogen deficiency, there was an increase in number of days to tasselling, anthesis and maturity of the crops. The experiments of Ologunde and Ogundela (1985) were both carried out in water deficit agro-ecologies and might explain the outcome of their results.

Intercropping maize with soybean as late season crops and the pattern in which the crops were arranged in relation to one another had profound effect on the growth, development and productivity of the component crops. The growth attributes of number of leaves per plant in 2008, plant girth and leaf area index in maize and also the number of leaves per plant and the number of branches per plant in soybean in both years, were greatly reduced in mixture compared to their sole crop performance from 8 to 10 weeks after sowing. The non significant responses in the number of leaves per plant, stem girth and leaf area index in maize from early growth to 6 weeks after sowing indicated that there was little or no inter-specific competition for the available resources at these earlier growth stages. This observation agrees with the reports by Keating and Carberry (1993) and Ennin *et al.* (2002) on solar radiation capture and utilization in intercropping. From 8 to 10 weeks after sowing, competition ensured, resulting in depression of the vegetative parameters of the intercrops, compared to sole crops. This resulted in the significant increase in plant height due to shading effect and a reduction in number of leaves per plant and plant girth. Increased plant height and decreased stem girth, reduced branching and decreased leaf production of the lower component crops were reported to be typical responses in intercrops due to increased far: red ratio of light intercepted at the lower level of the intercrops canopy (Keating and Carberry, 1993). Reduction in the number of branches has also been linked to lack of light at the lower canopy. Reduced branching means reduced number of leaves in soybean as observed in this study. Similar to this result Carr *et al.* (1995) found that intercropping wheat and lentil increased lentil plant height in mixture compared to its sole crop. Ennin *et al.* (2002) obtained increased plant height, reduced number of branches, leaves and leaf area index of soybean when intercropped with maize. The increase in lentil plant height and the decrease in soybean agronomic components were all attributed to mutual shading by the intercrops.

Maize also suffered the consequences of intercropping. Maize growth parameters of stem girth, leaf area index, number of leaves per plant and plant height in, 2008 were significantly reduced by intercropping compared to sole cropping at 8 to 10 weeks after sowing. The effect of intercropping on these parameters in maize might be due to intra-and inter-specific competition. Additive intercropping or crop arrangement appeared not to be a critical factor in determining number of days to 50% tasselling in maize or flowering in soybean. This is probably because the level of competition within each crop arrangement did not varied enough to influence tasselling or flowering in this experiment. Similar to our observation Chiezey *et al.* (2004) found no significant response to crop arrangement in number of days to 50 percent flowering in soybean or sorghum grown as intercrops.

Stover and haulm yields responded positively to nitrogen application. In maize, the highest dry matter was obtained at 100 kg N $ha^{-1}$, thus confirming the importance of nitrogen to its growth and development. In soybean, the optimum response to nitrogen was at 50 kg N $ha^{-1}$, probably because the crop depended more on the symbiotically fixed nitrogen than the applied nitrogen. The effects of intercropping and crop arrangement on stover and haulm yields were consistent over the years. Among the intercrop arrangements, planting two rows of maize to 2 rows of soybean and one row of maize to two rows of soybean were superior to planting the crops in single alternate rows. It can therefore be concluded that though the populations were additives, the 2:2 and 1:2 intercrop arrangements offer better opportunities for late season maize and soybean intercropping to utilize available resources more effectively than the 1:1 arrangement.

## CONCLUSION

This study demonstrated the roles of nitrogen and crop arrangement on growth and development of maize/soybean as sole crops and maize/soybean intercropping in the humid agro-ecology of Nigeria. From the results obtained in this study it is evident that nitrogen fertilization up to 100 kg $ha^{-1}$ improved plant growth and development, especially that of the sole, late season, maize. However 50 kg N $ha^{-1}$ appears to be the optimum for growth and development of soybean or maize/soybean intercropping in the humid agro-ecology of South Southern Nigeria. Intercropping therefore reduces the nitrogen fertilizer need for growth and development of maize/soybean intercrops. Intercropping maize and soybean at 2:2 or 1:2 intercrop arrangement produced higher stover and haulm yields in late season maize in this humid agro-ecology of South Southern Nigeria.

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