IASET: International Journal of Agricultural & Bio-Chemical Science (IASET: IJABS)
ISSN(P): Applied; ISSN(E): Applied
Vol. 1, Issue 1, Jan - Jun 2017; 1-8

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

RELATIVE TIME OF PLANTING AND SPATIAL ARRANGEMENT FOR SOYBEAN/MAIZE INTERCROPPING IN FOREST-SAVANNAH ECO-CLIMATIC ZONE OF NIGERIA

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ABSTRACT

The relative planting time and spatial arrangement for intercropped soybean/maize in forest savannah eco-climatic zone was investigated in this study. In an attempt determine the best planting date and spatial arrangement for the intercrop, two spatial arrangements: soybean in alternate rows with maize and double rows of soybean between double rows of maize and seven relative planting times of planting the component crop (planting of soybean 30, 20 and10 days after maize, simultaneous and planting soybean, 30, 20, 10 days before maize). Each plot measured 6.5m x 7.5m on randomized complete block design in a 2x7 factorial with 2 sole crops. The yield characteristics (pods/plant, seed/pod and grain yield) decreased with delayed planting for intercropped soybean planted after maize, while it increases with delayed planting with intercropped soybean planted before maize. Intercropped maize yield were significantly higher when planted before soybean. Double rows of soybean and single rows of maize arrangement showed lower yield than alternating rows maize and soybean arrangement. Soybean/maize intercropping in alternate rows could be recommended as more productive, sustainable and alternative to growing maize or soybean as monocrops in forest savannah eco-climatic region of Nigeria

KEYWORDS: Planting Time, Spatial Arrangement, Soybean/Maize-Intercropping, Sustainable Farming System, Optimum Yield

INTRODUCTION

Climate variability and change have a direct, often adverse influence on the quantity and quality of agricultural production. Rainfall, temperature, humidity, sunshine hours are important climatic elements that influence crop production. While rainfall is one of the principal limitations to increased productivity, the distribution of water within the soil profile and therefore the proportion that remains in the root zone for the plant to utilize, appears to be a more crucial limitation than total rainfall (Nnaji, 2001).

The growth of two crops together on the same field during the growing season may result in inter-specific completion or facilitation between the plants (Zhang and Li, 2003) Thus , the overall mixture densities and relative proportions of component crops are important in determining yield and production efficiency of intercrop system (Willey and Osiru, 1982).

Improving sustainability is a process that moves farming system along a trajectory towards meeting various socially determined sustainable goals as opposed to achieving any particular end state. The sustainability of a farming practice or system could be evaluated on the basis of how well it meets various societal goals or objectives. To be sustainable, farming system need to be sufficiently productive, robust (that is, be able to meet the goals in the face of stress and fluctuating conditions, use resources effectively and balance all the goals). One of the most useful sustainable farm practices employed in recent decades is the old, but undervalued practice of intercropping. In terms of land use efficiency, intercropping is regarded as more productive than sole cropping (Marer, 2007). Higher nutrient uptake and better water use efficiency have also been suggested (Odhiambo and Ariga, 2001). Various reasons have been given for adoption of this system (Giller and Wilson, 1993). These include the risk of crop losses due to adverse environmental conditions, need for balanced diet and desire to optimize the use of labour and to optimize the use of land. The advantage is often expressed as land equivalent ratio (LER), which is greater than and indicates that more sole cropped land intercropped is required to produce a given amount of product. The LER of maize-soybean intercrop ranged from 0.98 – 1.55 in Zambia (Keating and Carberry, 1993) and 1.2 – 1.8 in Ethiopia (Jiao *et al*., 2008). Legume contributes additional nitrogen to the soil, which can be used by the compound crop in the intercrop. Soybean intercropped with maize has been reported by several scientists in Australia, Zimbabwe and United States of America (Heitholt *et al*., 2005; Mulongoy et al 1992). The relative time of planting in a component crop is also an important management variable manipulated in intercropping. Andrew, (2002) pointed out that differential sowing dates improves productivity and minimizes competitions of growth-limiting factors in intercropping. Willey (2009) also pointed out that sowing component of crops at different times causes full utilization of growth factors because crops occupy the land throughout the growing season.

The use of soybean dates back to the beginning of China's agricultural age. For centuries, soybean has meant meat, milk, cheese, bread and oil in various countries. This explains why this crop has often been referred to as "cow of the field" or "gold from the soil". Recognizing soybean as the golden bean or miracle bean, the western world provided a massive push towards its growth during the early parts of the century. The crop in fact has revolutionized the agricultural economy of the USA with its immense potential for food, feed and numerous industrial products. Soybean has come to be recognized as one of the premier agricultural crops today for various reasons. In brief, soybean is a major source of vegetable oil, protein and animal feed. Soybean, with over 40 percent protein, and 20 percent oil has now been recognized all over the world as potential supplementary source of edible oil and nutritious food. The protein of soybean is called a complete protein, because it supplies sufficient amounts of the kinds of amino acids required by the body for building and repairs of tissues.

Maize has been in the diet of Nigerians for centuries and it is a versatile crop on which many agro-based industries depend as raw materials. For many people and civilizations, maize has since ancient times been a food, feed, commodity, construction materials, fuel, medicine or decorative plant. Its grain, stalk, leaves, cobs, tassels and silks have commercial values in most settings, though that of the grain is the greatest. With the industrial development, it is increasingly becoming an industrial raw material for the production of starch, gluten, oil, flavour, grits, alcohol and lingo-cellulose for further processing into a whole range of products and by-products. About 75 percent of the kernel in starch, but the content depends on the maize type and variety. Starch is an important source of energy. Endosperm composition may be modified to meet various needs.

The objective of this study were to determine the growth and yield of soybean intercropped with maize and to investigate the relative time of planting and spatial arrangements on the productivity of soybean/maize intercrop in forest-savannah eco-climatic zone of Nigeria.

MATERIALS AND METHODS

This research was conducted during the growing season of 2014 at the research farm of the University of Agriculture, Abeokuta ($7^0$15`N; $30^0$25`E). The soil of the experimental site was a well-drained tropical ferruginous soil classified as sandy-loam (Bello, 1996). The forest-Savannah eco-climatic zone of Nigeria covers a total land area of about 115,000 sq. km. Rainfall in the zone can be described as humid to sub-humid tropical with distinct dry and wet season. The dry season runs from early November to end of March, while the wet season is from early April to early November. There are two rainfall peaks (June and September) with a dry spell in August. Annual temperature ranges between 28 – 36 ^{0}C. Relative humidity is high throughout the year and ranged between 60 – 90 percent at 16.00 hours. A sunshine hour is directly related to cloud, while average daily sunshine hours ranged from 14 hours in August to 7.5 hours in January.

Each plot measured 6.5m x 7.5m on randomized complete block design consisting of 16 treatments in a 2x7 factorial with 2 sole crops. The factors under study were (i) two spatial arrangements: soybean in alternate rows with maize and double rows of soybean between double rows of maize and (ii) seven relative planting times of planting the component crop: planting of soybean 30, 20 and10 days after maize, sole soybean planting, sole maize planting, simultaneous and planting soybean, 30, 20, 10 days before maize.

The result of the pre-planting soil analysis indicates soil pH of 6.7, organic matter and organic carbon of 2.10 and 1.06 % respectively. The exchangeable bases were Ca (2.34 cmol kg^{-1}) and cation exchange capacity (2.75 cmol kg^{-1}). The land was ploughed twice and harrowed once. Three seeds per hole were planted and later thinned to two per stand at one week after planting. Weeding was carried out manually using hoe at two weeks after planting and at two weeks interval. The first planting date will be at onset of rainfall for simultaneous and other relative planting times. The treatment combination is as shown in Table 1.

Two types of data were utilized: climate and crop growth-yield data. Climatic data to be collected is rainfall temperature and relative humidity, while the growth and yield data include number of leaves, plant height, leaf area pods per plant, seeds per pod and yield per hectare of maize and soybean. Crop growth data were collected weekly starting from a week after planting and subsequently at one week interval. Mean separation of the different treatments using Duncan multiple range test (DMRT) was employed for computation.

Table 1: Treatment Combination and Days of Planting

Treatment Code	Description
T_1S_1	Maize planted same day with soybean, soybean in alternate rows
T_1S_2	Maize planted same day with soybean, soybean in double rows
T_2S_1	Maize planted 10 days before soybean, soybean in alternate rows
T_2S_2	Maize planted 10 days before soybean, soybean in double rows
T_3S_1	Maize planted 20 days before soybean, soybean in alternate rows
T_3S_2	Maize planted 20 days before soybean, soybean in a double rows
T_4S_1	Maize planted 30 days before soybean, soybean in alternate rows
T_4S_2	Maize planted 30 days before soybean, soybean in a double rows
T_5S_1	Maize planted 10 days after soybean, soybean in alternate rows
T_5S_2	Maize planted 10days after soybean, soybean in double rows

T_6S_1	Maize planted 20 days after soybean, soybean in alternate rows
T_6S_2	Maize planted 20 days after soybean, soybean in double rows
T_7S_1	Maize planted 30 days after soybean, soybean in alternate rows
T_7S_2	Maize planted 30 days after soybean, soybean in double rows
Sole maize	Sole maize
Sole soybean	Sole soybean

RESULT AND DISCUSSION

Table 2 shows the result of selected growth and yield parameters of intercropped and sole soybean planted under spatial arrangement. The average leaf area was generally greater in intercropped soybean planted before maize than sole soybean and intercropped soybean planted after maize. Intercropped soybean in alternate rows with maize performed better than in double rows of soybean with single rows of maize irrespective of the date of planting. Leaf area reduces with delayed planting on intercropped soybean planted after maize, while it increases with delayed planting in intercropped soybean planted before maize irrespective of planting arrangement.

The yield characteristics (pods/plant, seed/pod and grain yield) decreased with delayed planting for intercropped soybean planted after maize, while it increases with delayed planting with intercropped soybean planted before maize. The results further shows that double rows of soybean between single rows of maize arrangement had significantly lower yield than alternate row of soybean and maize. This may be as a result of interplant completion for radiation and nutrient being higher in double rows of soybean and single rows of maize than in alternating rows of maize and soybean. These trends also showed that there is a positive correlation between growth parameters of inter cropped soybean at varying planting dates. Yield characteristics of intercropped soybean irrespective of the arrangement are significantly lower than sole soybean.

Table 2: Result of Selected Growth and Yield Parameters of Intercropped and Sole Soybean Planted Under Different Spatial Arrangement during 2013 Planting Season

Planting Time X Spatial Arrangement	Average Leaf Area (cm^2)	Pods/Plant	Seed/Pod	Grain Yield (kg/ha)
T_1S_1	1056	18.5	3.20	4200
T_1S_2	1028	16.2	2.86	3200
T_2S_1	1015	18.0	2.68	3500
T_2S_2	962	15.7	2.08	2300
T_3S_1	986	17.5	2.36	2500
T_3S_2	866	14.5	1.98	2100
T_4S_1	621	9.1	1.82	2345
T_4S_2	528	6.0	1.62	2015
T_5S_1	1388	28.6	3.86	8700
T_5S_2	1266	22.6	3.00	5400
T_6S_1	1876	29.6	3.40	9800
T_6S_2	1489	24.1	2.86	3200
T_7S_1	1901	32.1	3.84	9600
T_7S_2	1508	25.2	3.22	7800
Sole soybean	1204	26.5	3.28	10040
LSD	35.8	2.5	1.02	210.6
%CV	8.5	9.8	11.2	17.5

The result of physiological characteristics of maize planted in intercropping system of maize and soybean at different spatial arrangement is as shown in Table 3. The selected growth characteristics (plant height and stem girth) increases with delayed planting in intercropped maize planted after soybean while it reduces with delayed planting with maize planted before soybean. The same trend was also observed in terms of yield characteristics. Intercropped maize yield were significantly higher when planted before soybean. Double rows of soybean and single rows of maize arrangement showed lower yield than alternating rows maize and soybean arrangement. All these are in agreement with Ullah *et al* (2007) where he reported a reduced intercrop yield when they investigated the effects of component density on the yield of sorghum intercropped with cowpea. Aliyu (2010) also confirmed that yield component crops varied with the row arrangement of the crop. That sole crop of sorghum and cowpea recorded higher values for both grain and Stover yield.

Also, sole maize planting had the overall highest (2400kg/ha) yield, while maize planted 30 days before soybean had the highest intercropped yield.

Table 3: Result of Selected Growth and Yield Parameters of Intercropped and Sole Maize Planted Under Different Spatial Arrangement during 2013 Planting Season

Planting Time X Spatial Arrangement	Plant Height (cm) At 10WAP	Stem Girth (cm) At 10WAP	Grain Yield (kg/ha)
T_1S_1	163.2	7.0	2115.0
T_1S_2	157.8	6.8	1945.0
T_2S_1	175.2	7.2	2158.0
T_2S_2	157.7	6.8	2064.0
T_3S_1	197.5	8.4	2065.0
T_3S_2	185.2	8.0	2215.0
T_4S_1	197.6	7.1	2285.0
T_4S_2	187.6	5.4	2264.5
T_5S_1	150.3	5.2	1887.4
T_5S_2	143.4	5.0	1616.9
T_6S_1	163.5	5.8	1892.2
T_6S_2	158.4	5.0	1686.9
T_7S_1	188.5	6.2	1882.0
T_7S_2	162.5	5.4	1765.4
Sole maize	198.5	8.8	2400
LSD	22.5	2.8	122.4
%CV	7.6	11.3	18.2

The variations in terms of growth and yield of intercropped soybean and maize planted in 2014 witnessed the same trend as those planted in 2013. (Tables 4 and 5). The growth and yield performances of the component crops were lower than that planted during the 2013 planting season. The relative time of planting of soybean and maize influenced the grain yield of the crops. Intercropping and crop arrangement on yield characteristics were significant both in the two planting periods. Highest yield of soybean (8640 kg/ha) was found on the one planted as sole and at intercropped, it was found the highest was the one planted at soybean planted 20 days before maize, in alternate rows. While highest maize yield (2004 kg/ha) was found on the one planted as sole, the intercropped maize planted 30 days before soybean, soybean in alternate rows had the highest grain yield (1906 kg/ha). Among the intercrop, planting maize after soybean produced lower grain yield than planting before soybean irrespective of the year planting.

Table 4: Result of Selected Growth and Yield Parameters of Intercropped and Sole Soybean Planted Under Different Spatial Arrangement during 2014 Planting Season

Planting Time X Spatial Arrangement	Average Leaf Area (cm^2)	Pods/Plant	Seed/Pod	Grain Yield (kg/ha)
T_1S_1	986.4	14.4	2.80	3480
T_1S_2	908.2	12.5	2.20	2846
T_2S_1	900.1	15.0	1.80	3056
T_2S_2	862.5	13.2	1.46	2088
T_3S_1	788.4	12.8	1.80	2055
T_3S_2	746.0	10.2	1.42	1982
T_4S_1	565.2	6.8	1.40	1986
T_4S_2	462.2	6.0	1.22	1744
T_5S_1	1051.0	18.4	2.86	4057
T_5S_2	1012.2	16.2	2.40	3054
T_6S_1	1468.2	19.0	2.96	6800
T_6S_2	1215.6	18.0	2.42	4200
T_7S_1	1714.0	20.6	2.86	6200
T_7S_2	1368.0	15.0	2.46	5240
Sole soybean	966.4	18.2	2.45	8640
LSD	75.6	3.4	1.2	201
%CV	11.5	7.1	8.2	11.8

Table 5: Result of Selected Growth and Yield Parameters of Intercropped and Sole Maize Planted Under Different Spatial Arrangement during 2014 Planting Season

Planting Time X Spatial Arrangement	Plant Height (cm) At 10WAP	Stem Girth (cm) At 10WAP	Grain Yield (kg/ha)
T_1S_1	146.3	6.8	1904.2
T_1S_2	135.7	6.0	1563.4
T_2S_1	150.1	6.8	1896.2
T_2S_2	133.4	6.1	1804.1
T_3S_1	156.5	7.2	1798.0
T_3S_2	150.7	7.0	1801.2
T_4S_1	148.2	6.8	1906.2
T_4S_2	132.4	6.0	1886.5
T_5S_1	130.8	4.8	1662.5
T_5S_2	129.7	4.8	1446.2
T_6S_1	142.5	4.6	1562.5
T_6S_2	131.2	4.6	1462.0
T_7S_1	150.4	5.8	1568.2
T_7S_2	132.5	4.4	1482.4
Sole maize	163.9	7.2	2004.6
LSD	4.08	1.05	105.6
%CV	3.7	5.7	8.2

CONCLUSIONS

Owing to this present reality of global warming, relative time of planting is a critical management strategy aimed at determining the growth and yield of crops vis-a-vis adapting and mitigating against climate change. The result form this study had demonstrated that relative time of planting and spatial arrangement are important factors in determining the yield and productivity of maize/soybean intercrop. Relative time of planting soybean and maize significantly influence grain yield. Grain yield of component crop was significantly affected by spatial arrangement. Alternate rows of soybean had higher intercrop productivity than double row of soybean. Farmers in this agro-ecological zone are therefore advised to superimpose sole cropping to intercrop maize/soybean at alternate rows for optimum income benefit associated with the system. Soybean/maize intercropping could be recommended as more productive, sustainable farm practice and alternative to growing maize or soybean as monocrops in forest savannah eco-climatic region of Nigeria.

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