Agronomic Evaluation of Performance of Sesame Varieties in Maize-based Intercropping System in The Southern Guinean Savanna of Nigeria

A. T. Ajibola, [1] and G.O. Kolawole[1],

[1]*Department of Crop Production and Soil Science Ladoke Akintola University of Technology, Ogbomoso, Nigeria*

Correspondence should be addressed to Ajibola , A.T

E mail: toopeshow@gmail.com

ABSTRACT

Aims: Field experiments were conducted to determine compatibility of sesame varieties for intercropping with maize.

Study design: The experiment was a randomized complete block design with three replications.

Place and Duration of Study: Teaching and Research Farm, LAUTECH, Ogbomoso, southern guinea savanna area of Nigeria during the 2010 and 2011 cropping seasons

Methodology: The treatments included Sole maize (Oba super 1 variety), five sole sesame varieties (E-8, O3l, O1m, O2m, Exotic-sudan) and their intercrops, making a total of eleven treatments. Sole maize was planted at a spacing of 75 cm x 25 cm. For intercrops, maize was planted at a spacing of 100 cm x 25 cm and sesame seeds were planted at a spacing of 100 cm x 10 cm such that sesame row alternated maize row. Maize was planted first and sesame was introduced two weeks after.

Results: Intercropping maize with sesame varieties significantly (P = 0.05) reduced number of pods and grain yield of sesame varieties in both years. However, variety O2m produced grain yield in the intercrop similar to the monocrop. Generally, Intercropping sesame with maize significantly reduced the grain yield of maize by 36% compared to the sole crop. Exotic-sudan varieties caused highest percentage yield producing (52%). Sesame varieties O2m and O3l were the only varieties whose yield advantage in intercropping with maize had land equivalent ratio (LER) of 1.28 and 1.18 while other varieties had values less than 1 indicating better advantage of O2m and O3l with maize. The relative crowding coefficient (K) value of maize (4.98) was higher than sesame (0.44) thus indicating its dominance in the mixture.

Conclusion: It is therefore suggested that the prospective sesame farmers could grow O2m and O3l in place of the popular E-8 because intercropping did not affect their performances in both years.

Keywords: sesame varieties, maize, intercropping, crop compatibility, derived savanna transition zone

1. INTRODUCTION

Traditional agriculture, as practiced through the centuries, has always included different forms of intercropping. Farmers intermingled a variety of crops, in the same field, to sustain themselves and their families. In many developing countries, traditional agricultural systems are based on the growing of crops in mixtures [1]. According to [2], multiple cropping is the most dominant cropping system in Nigeria and it is the best cropping system for the soil of the humid tropics. Intercropping has been associated with such advantages as better utilization of environmental factors, greater yield stability, soil protection, variability of food supply, increasing the return per unit area and insurance against crop failure [3]. Intercropping using improved cultivars of crop and improved agronomic practices remains the most feasible approach to optimize crop production and maximize the use of available land [4].

In most traditional cropping systems in Nigeria, maize is one of the most prominent crops severally intercropped with assorted crops thereby forming an integral component of various cropping systems [5]. It is the most popular cereal due to its high yielding, ease of processing and easy digestibility than other cereals [6]. Also, it is a versatile crop that grows across a range of agro-ecological zones [7].

Sesame *(Sesame indicum* L.) also known as beni-seed belong to the Pedaliaeace family and genus Sesamum (Falusi, 2007) [8].. Sesame is a fairly high valued food crop harvested for its whole seeds (Jefferson, 2002) [9].. It is one of the most ancient crops grown for its oil rich seeds. It is increasingly gaining popularity in Nigerian agriculture because of the economic importance of its seeds in the world market and the nutritional content of its leaves when used as vegetable (Olowe *et al.,* 2003) [10].. Sesame seeds are also used in various food preparations, raw or roasted The seeds are unusually high in oil around 50% and protein content of 21% (Bennett *et al.,* 2003) [11]. which is highly comparable to those of other prominently grown legumes including groundnut and soybean. Sesame oil is colourless and odourless. The presence of important antioxidants such as sesaminol, sesamolinol and tocopherol makes sesame oil highly preserveable as it does not get rancid [12]. The high demand for sesame has also been attributed to the fact that products from sesame meet the health requirements for food in the developed countries and has become an important part of their diet [13]. After the oil is extracted from the seed, the remaining meal is a high protein material suitable for feeding livestock [9]. The oil is also used as carrier for medicines and perfumes and as synergist for pyrethrin-based insecticides. Poor grades are used in the production of soaps, paints, lubricants and lamp oil [14]. Nonetheless, in spite of its multi-dimensional uses, the commercial and mechanized cultivation of sesame in Nigeria is not very encouraging and its yield is very low. On average 500 kg of sesame seeds is harvested per hectare in Nigeria [15] which is much lower than the average yield of other countries including Egypt (1120 kg ha^{-1}), Mexico (960 kg ha^{-1}) and China (900 kg ha^{-1}) [16].

The crop is grown under a range of environments, which probably affects its performance. The environmental factors that influence sesame productivity include climatic factors such as temperature, rainfall and day length, soil types and management practices such as plant densities, time of sowing, irrigation, fertilizers, herbicides and fungicides, some of which may partially mitigate others [17;18]. Among the measures adopted to increase the production of sesame is the introduction of new varieties with high yield potentials as well as application of suitable cultural practices such as fertilization, and weed control etc.

Sesame had been successfully introduced into cropping systems in the different major growing and potential growing areas in Nigeria often grown as a sole crop, as well as in mixtures with cereals. Its integration into the farming systems reduces the risk of crop failure associated with growing sesame in pure stand and put less demand on labour and fertile land, both of which are limited in supply. The integration also restores soil fertility and suppresses weed [19].
Broadly speaking, the traditional cropping system is prone to the use of low yield crop cultivars, which results in low yield, due partly to species compatibility problem due to problems of severe competition [20; 21; 22;23].
Maximization of yields in crop mixtures will always be on the basis of high species compatibility [24]. and the minimization of above and below ground competition for growth [25]. Crop compatibility is the most essential factor for the intercropping system. The success of any intercropping system depends on the proper selection of crop species where competition between them for light, space, moisture and nutrients is minimum [22; 23]. A careful selection of crops could reduce competition to a considerable extent [26] increase overall production per unit of land and time [27]. As it is not all crops that grow well in mixtures, a careful study is necessary to assess the compatibility of different varieties to be intercropped. Therefore, there is the need to develop sustainable system which will maximize gains from high compatibility with other crops. Thus, the objective of this study was to evaluate the compatibility of sesame varieties for intercropping with maize.

2. MATERIALS AND METHODS

2.1 Experimental site

The experiment was carried out at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeria between 3rd june and 20th November in 2010 and 7th May and 28th October in 2011. The climatic condition of the area is mostly influenced by the north-east trade wind and the south-west trade wind. The area has a minimum temperature of 28 ^{0}C and a maximum of 33 ^{0}C. The humidity of the area is high (74%) all year round except in January when the dry wind from the north flows in. The annual rainfall of the area is between 1150 mm-1250 mm.

2.2 Treatments and experimental design

Maize (Oba super 1 variety) and five sesame varieties (E-8, O3l, O1m102-115, O2m, Exotic-Sudan) were used for the experiment. Oba super 1 is white coloured maize developed by Premier Seed, Nigeria

Limited of Chikayi Industrial Estate, Zaria. The hybrid maize was selected on the basis of its high yield, adaptability to the climatic zone and its resistance to diseases, especially striga. Sole maize, five sole sesame varieties (E-8, O3l, O1m102-115, O2m, Exotic-Sudan and their intercrops were laid out in a randomized complete block design with three replications. Making a total of eleven treatments. The total experimental area was 16 m x 27 m (432 m^2) and plot size was 4 m x 3 m. Each replicate measured 4 m x 27 m (108 m^2) separated by a 2 m path.

Planting and Cultural Practices

For sole sesame plantings, two pinch of seeds were planted per hole at a spacing of 60 cm x 10 cm and later thinned to one plant per stand to give a plant population of 16666.67 plant/ha [16]. Also for sole maize, two seeds were planted per hole at a spacing of 75 cm x 25 cm and the seedlings later thinned to one stand to give a plant population of 533.33 plants/ha. For intercrops, maize was planted at a spacing of 100 cm x 25 cm and sesame seeds were planted at a spacing of 100 cm x 10 cm. Sesame row alternated maize row, that is, sesame was planted in between 2 maize rows. Maize was planted first on the 3rd June in 2010 and 7th May in 2011. Sesame was introduced two weeks after in both years [19]. Weeding was done with the native hoe at 3 and 6 weeks after planting (WAP). The recommended ate of compound fertilizer NPK (15:15:15) for sole maize: 100 kg N ha^{-1}, 40 kg P ha^{-1} and 60 kg K ha^{-1}; for sole sesame: 30 kg N ha^{-1}, 30 kg P ha^{-1} and 30 kg K ha^{-1} and for maize-sesame intercrop: 100 kg N ha^{-1}, 100 kg P ha-1and 100 kg K ha-1 were applied [28]. The band method of fertilizer application was employed. The fertilizer was applied twice to each plot at 3 and 6 WAP.

2.3 Harvesting and data collection

Ten maize and sesame plants were randomly selected from the net plot (3 m x 2 m) and tagged for collection data. Data were collected on number of pods of sesame per plant, sesame seed weight (g/plot) and maize grain weight (g/plot). Numbers of pods per plant were determined by direct counting followed by total seed weight obtained from the net plot (3 m x 2 m) converted to the seed yield (kg ha^{-1}). Sesame harvesting commenced on 4th October in 2010 and 4th September in 2011, when lower leaves, pod and stem turned to lemon yellow colour. Harvesting was done by cutting the plants from ground level and these were bundled. Bundles of harvested plants were sun dried. Fully matured maize cobs were harvested on 12th November in 2010 and 7th September in 2011, when the leaves turned yellowish and fallen off, which were signs of senescence and cob maturity [29]. The maize cobs were fully dried and dehusked after which the grains were separated from the cob. The seeds were winnowed, cleaned and weights of seeds obtained from each net plot were recorded. Data were collected on the number of capsules per plant of sesame and yield of maize and sesame.

Intercropping indices
The various intercropping indices were worked out.

Land equivalent ratio (LER)

Land equivalent ratio (LER) was used as criterion for measuring efficiency of intercropping advantage . When the value of LER is greater than one, the intercropping favors the growth and yield of the species. When LER is lower than one the intercropping negatively affects the growth and yield of crops grown in mixtures and if LER is = 1, then it indicates no profit, no loss from the intercropping. Land equivalent ratio (LER) was calculated using the formula of [30]:

$LER = (Ls + Lm)$

$Ls = (Ysm/Yss)$

$Lb = (Yms/Ymm)$

Where Ysm = sesame seed yield in mixture,
Yss = sesame seed yield in pure stand
Yms = maize grain yield in mixture
Ymm = maize seed yield in pure stand

Land equivalent coefficient (LEC)

Land equivalent coefficient (LEC) was calculated to measure the intercrop interaction using the formula of [31]:

LEC = (Ls x Lm)

Relative crowding coefficient (K)

Relative crowding coefficient (K) was calculated to measure the dominance of one species over the other in the mixture using the formula of [32]:

K = Ks X Km

Where Ks = Ysm x Zms / (Yss -Ysm) x Zsm and

Km = Yms x Zsm / (Ymm -Yms) x Zms

Zsm = proportions of sesame in the intercrop and

Zms = proportions of maize in the intercrops

When the value of K is greater than 1, there is a yield advantage, when it is equal to 1, there is no yield advantage and if less than 1 there is no yield advantage and the system has disadvantage.

Competitive ratio (CR)

Competitive ratio (CR) was calculated to measure the degree with which one crop competes with the other using the formula of [33]:

CR (sesame) = Ls x Zsm/Lm x Zms

CR (maize) = Lm x Zms/Ls x Zsm

System productivity index

System productivity index was calculated using the formula of [34]:

SPI = (Yss / Ymm X Yms) + Ys

Data Analysis

Data was analyzed using analysis of variance (ANOVA) and means where compared using least significant difference (LSD) at 5% level of probability [35].

TABLE 1: Details of sesame varieties used In this study

Variety	**Days to Maturity**	**Seed Color**	**Seed size mm**	**Oil Content**	**Potential Yield kg/ha**
NCRIBEN-OIM	102-115	White	3	45%	1000
NCRIBEN-02M	102-115	Light brown	3	45%	750
NCRI BEN-032	125-140	Brown	2	40%	600
E-8	90	White	3.6	50%	1000
Exotic-Sudan	90	White	2.0	50%	1200

Source: [36; 37].

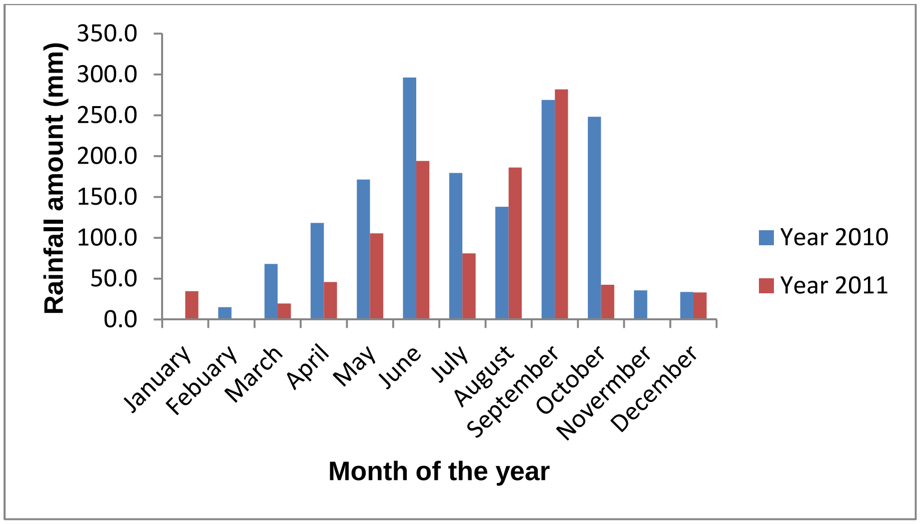

Figure 1: Rainfall Record of the Study Area in Year 2010 and 2011

3. RESULTS AND DISCUSSION

Rainfall Record of the Study Area

The total annual rainfall of study area was 1539.3mm and 990.3mm in 2010 and 2011 respectively (Figure 1). The highest total annual rainfall was recorded in the year 2010 which was above the average of the study area (1150mm-1250mm).

3.1 NUMBER OF POD AND YIELD PARAMETERS OF SESAME VARIETIES

The effect of cropping system on number of pods and seed yield of sesame is as presented in Table 2 and 3. Cropping system had significant effect (P = 0.05) on the number of pods and seed yield of sesame in both planting seasons. Significantly higher numbers of pods and seed yield were recorded in the sole cropping system.

There was no significant difference in the seed yield of the intercropped sesame except in 2010. Among the intercropping treatments in 2010, O3l and O2m recorded significantly higher seed yield while O1m produced the least.

Variety had no significant effect (P = 0.05) on number of pods per plant except on sesame seed yield. However, in 2010 planting season, significantly higher seed yield was recorded in the O31 variety which was comparable to O1m and E-8 varieties, while the least seed yield was recorded in the Exotic- Sudan variety. In 2011 planting season, significantly higher seed yield were recorded in the E-8 variety which was comparable to O1m and O31 varieties, while the least seed yield was recorded in the Exotic – Sudan and O2m varieties.

3.2 SEED YIELD OF MAIZE

The effect of intercropping on maize grain yield is as presented in Table 2. Grain yield of maize measured in all the intercrop plot was significantly (P = 0.05) reduced compared to the sole crop in 2010. However in 2011, sole maize yield (2188 kg/ha) was comparable to values recorded in maize plots intercropped with o1m (2090 kg/ha) and o2m (1911 kg/ha) varieties.

Table 1:Effect of cropping system on number of pods/plant

Variety	Cropping system (2012) Sole	Intercrop	mean	Cropping systems(2011) sole	Intercrop	mean
NCRI BEN-01M	72	14	43	53	12	32
NCRI BEN-02M	43	22	32	41	20	31
NCRI BEN-03L	73	32	53	53	24	38
E-8	87	16	51	81	14	47
Exotic-Sudan	59	14	37	45	12	29
Cropping system Mean	67	20		55	16	

Lsd cropping system 2010: 15
Lsd variety 2010 : ns
Lsd cropping system 2011 : 19
Lsd variety 2011 : ns

Table 2:Effect of cropping system on seed yield (kg/ha)

Variety	Cropping system (2012) Sole	Intercrop	mean	Cropping systems (2011) sole	Intercrop	mean
NCRI BEN-01M	466.22	72.97	190.84	331.70	49.78	269.60
NCRI BEN-02M	266.23	145.67	132.45	177.33	81.57	205.95
NCRI BEN-03L	469.33	227.31	236.33	376.00	96.67	348.32
E-8	489.00	103.31	276.38	471.00	81.77	296.16
Exotic-Sudan	241.67	82.10	111.95	184.33	39.57	161.88
Cropping system mean	386.49	126. 2 7		308.1 1	71.07	

Lsd cropping system 2010 : 70.88
Lsd variety 2010 : 112.08
Lsd cropping system 2011 : 84.27
Lsd variety 2011 : ns

Table 3: Effect of cropping system on maize yield (kg/ha)

	2010 Maize yield (kg/ha)	2011 Maize yield (kg/ha)

Sole maize	2048	2188
O1m + maize	1492	2090
O2m + maize	1392	1911
O3l + maize	1468	1408
E-8 + maize	1224	1443
Ex-Sudan + maize	984	1209
Lsd (0.05)	672	909

Table 4: Effect of intercropping on of LER and K in maize-sesame intercrop

	2010			2011		
	LER	K of sesame	K of Maize	LER	K of sesame	K of maize
O1m + maize	0.91	0.19	2.68	1.11	0.18	2.1
O2m + maize	1.23	0.46	2.21	1.36	0.98	6.9
O3l + maize	1.20	0.94	2.53	1.16	0.35	1.81
E-8 + maize	0.80	0.29	1.49	0.83	0.21	1.94
Ex-Sudan + maize	0.83	0.51	0.92	0.76	0.27	1.24

Table 5: Effect of intercropping on of SPI, CR and LEC in maize-sesame intercrops

	2010				2011			
	SPI	CR of sesame	CR of maize	LEC	SPI	CR of sesame	CR of maize	LEC
01m + maize	1816	0.13	0.80	0.13	2418	0.14	0.87	0.14
O2m + maize	2038	0.38	0.56	0.38	2991	0.36	0.64	0.43
O3l + maize	2462	0.35	0.60	0.35	2553	0.45	0.55	0.33
E-8 + maize	1657	0.13	0.75	0.13	1823	0.20	0.80	0.11
Ex-Sudan + maize	1679	0.15	0.58	0.15	1679	0.28	0.72	0.12

3.3 Determination of LER, LEC, K, CR and SPI in maize-sesame intercrops

Land equivalent ratio (LER) and relative crowding coefficient (K)

The land equivalent ratio (LER) and relative crowding coefficient (K) of maize-sesame intercrops in 2010 and 2011 is presented in Table 4. A land use advantage (i.e. LER > 1) was recorded in O2m and O3l varieties over their sole crops. Intercropping maize into sesame with O2m and O3l resulted in LER 1.23, 1.20 and 1.36, 1.16 in 2010 and 2011, respectively. In both planting seasons land use advantage of intercropping O2m and O3l (1.28 and 1.18) was superior to that of sole crop, while other varieties had LER less than one. The total LER was highest with the O2m and O3l.

The total LER in sesame intercrop varieties in both years were less than 1.0, indicating that there was an intercropping disadvantage.

The relative crowding coefficient (K) values of maize was higher than sesame, thus indicating its dominance in the mixture. However, the sesame intercrop K values were less than 1, thereby indicating that sesame crop produced less yields than expected.

System productivity index (SPI), competitive ratio (CR) land equivalent coefficient (LEC)

The system productivity index (SPI), competitive ratio (CR) land equivalent coefficient (LEC) of maize-sesame intercrops in 2010 and 2011 is presented in Tables 5. The system productivity index (SPI) which standardized the yield of the secondary crop (sesame) in terms of the primary crop (maize) and also identified the combinations that utilized the growth resources most effectively and maintained a stable yield performance showed that the O3l and O2m varieties (2462 and 2991) gave the highest values than the other arrangements and monoculture in the year 2010 and 2011 respectively. The values of SPI were higher and largely determined by maize intercrop yields which were not much reduced by intercropping with sesame.

The CR values of maize were generally greater than those of sesame irrespective of crop combinations. Among the five sesame varieties, O1m had the highest CR maize values (0.82 and 0.87), while O2m had the highest sesame CR values (0.44 and 0.36) in year 2010 and 2011, respectively. Regardless of the intercrop variety, there was a positive sign for intercropped maize and a negative sign for the intercropped sesame, indicating that maize was dominant while sesame was dominated. The positive sign indicated the dominant crop while the negative sign indicated the dominated crop

Land equivalent coefficient (LEC), in terms of intercrop compatibility for the maize/sesame, O2m and O3l intercrop recorded LEC values (0.35, 0.37 and 0.43, 0.33) greater than 0.25 derived from the expected 50:50 yield ratio from a mixture of two crops.

DICUSSION

In the cropping season, intercropped number of pods per plant and sesame yields were generally low due to the shading effect by the taller and faster growing maize. This might probably have resulted due to reduction in solar radiation from shading by taller maize crops, which subsequently resulted in decreased yield. Generally, biomass production of shorter component crops is reduced by depression of photosynthesis due to reduction in solar radiation by shading of taller component crops. [41] had earlier reported reductions in both dry pod weight and dry grain yield of intercropped pigeon pea genotypes ascribing it to long competitive interactions with the traditional red sorghum, which, is endowed with unique proliferation of robust fine root network equipped for better competition for below-ground growth resources. It must also be noted that [42] also reported that intercropping with wheat decreased the number of pods per plant of mustard and chickpea. The higher yield variable recorded in the sole sesame compared to the intercrop in both years agrees with the findings of [43] and [44] in maize cowpea mixtures as well as [45] in corn soybean and sorghum soybean intercrops that the sole crop components produced yield higher than the corresponding crops in intercropping situation. The result is also in line with the findings of [46] who reported that shading of sesame plants result in lower yield.

The LER recorded in sesame varieties O2m and O3l which was greater than 1 indicated there was a yield advantage from the intercropping. This in line with the findings of [30]

The relative crowding coefficient (K) values of maize indicated its dominance in the mixture. The sesame intercrop K values were less than 1, thereby indicating that sesame crop produced less yields than expected, presumably due to inadequate utilization of resources. [30] that where the relative crowding coefficient of a particular crop species is less than, equal to or greater than 1, then that species produced less yield, the same yield or more than 'expected' yield, respectively. However this is in disagreement with the findings of [51] who reported that sesame grown in association with mungbean, mashbean and cowpeas utilized the resources more aggressively than the respective sole crops.

However, in terms of intercrop compatibility for the maize/sesame, O2m and O3l intercrop recorded LEC values greater than 0.25 derived from the expected 50:50 yield ratio from a mixture of two crops [31]. The other intercropping systems that recorded LEC < 0.25 could be described as not giving complementary yield. The effect of the dominant crop (Maize) on the intercrop (O2m and O3l) with LEC > 0.25 showed competitive complementarily.

The relative crowding coefficient (K) values of maize were higher than those of sesame, thus indicating its dominance in the mixture. [30] reported that where the relative crowding coefficient of a particular crop species is less than, equal to or greater than 1, then that species produced less yield, the same yield or more than 'expected' yield, respectively. The sesame intercrop K values were less than 1, thereby indicating that sesame crop produced less yields than expected, presumably due to inadequate utilization of resources. This is in disagreement with the findings of [51] who reported that sesame grown in association with mungbean, mashbean and cowpeas utilized the resources more aggressively than the respective sole crops.

The system productivity index (SPI) which standardized the yield of the secondary crop (sesame) in terms of the primary crop (maize) and also identified the combinations that utilized the growth resources most effectively and maintained a stable yield performance showed that the O3l and O2m varieties (2462 and 2991) gave the highest values than the other arrangements and monoculture in the year 2010 and 2011 respectively. The values of SPI were higher and largely determined by maize intercrop yields which were not much reduced by intercropping with sesame.

4. CONCLUSION

The two varieties (O2m and O3l) have intercropping potentials in the derived savanna transition zone. It is therefore suggested that the prospective sesame farmers could grow O2m and O3l in place of the popular E-8 because intercropping did not affect their performances in both years.

ACKNOWLEDGEMENTS

Authors acknowledge the effort of Miss Bolaji Afolabi who provided assistance in manuscript preparation.

COMPETING INTERESTS

Authors have declared that no competing interest exist.

AUTHORS' CONTRIBUTIONS

'Author A.T .Ajibola designed the study, wrote the protocol, and wrote the first draft of the manuscript. 'Author G.O. Kolawole performed the statistical analysis and .corrected the manuscript. All authors read and approved the final manuscript."

REFERENCES

1. Willey RW, and Osiru DS. Studies on Mixtures of maize and Beans (*Phaseolus vulgariis*) with Particular Reference to Plant Population. Journal of Agricultural Science, Cambridge. England. 1972; 79:517-529

2. Agboola AA. Current Programs, Problems and Strategies for Land Clearing and Development in Nigerian in Tropical Land for Sustainable Agricultural, Production. No.3 IBSRAM, Bangkok, Thailand.1987; 177-194.
3. Beets WC. Multiple Cropping and Tropical Farming System. West view press, Boulder, Company. 1982; 156 pp.
4. Adetunji AI. Growth and Yield of Intercropped *Sorghum bicolor*, and Sunflower Helianthus annum (L.) in Semi-Arid Nigeria. Journal of Agronomy and crop science. 1993;171:351-357
5. Ibeawuchi II. Intercropping-A Food production Strategy for The Resource poor farmers, Nature and Science. 2007;5(1)
6. Jaliya AM, Falaki AM, Mahmud M and Sani YA. Effects of Sowing Date and NPK Fertilizer Rates on yield and yield component of quality protein Maize (*Zea mays* L.) ARPN Journal Agricultural Biological Science. 2008;2: 23-29
7. Abuja Security and Commodity Exchange (ASCE). Maize (2008). Accessed 18 January 2014
8. Falusi OA. Segregation of Genes Controlling Seed Colour in Sesame (*Sesamum indicum linn*.) from Nigeria. African Journal of Biotechnology. 2007;6 (24):2780-2783
9. Jefferson T. Sesame a High Valued Oil Seed Growing Sesame Production Tips, Economics and Mare. 2003. http://www.jeffersoninstitute.org/pubs/sesame.shtml 15 April 20018.
10. Olowe VIO, Adeosun JO, Musa AA, Ajayi E. (2003). Characterization of Some Accessions of Sesame (*Sesamum indicum L*.) in a Forest-savanna Transition Location of Nigeria. Journal of Sustainable Agriculture and Environment. 2003; 5:119- 127.
11. Bennett MR, Hadss TM, Pocket Herb TM, and Webhadss TM (2003). Decision Aids For Field Crops. Weed Technol. 2003; 17(12):412-420.
12. Ahuja KI, Sekhon JS and Gupta TR (1971). Effect of some Cultural treatments on the yield and chemical composition of sesame (sesamum indicum L.) Ind. J. Agron. 16(4): 445-448.
13. Olowe VIO and Adeyemo AY. Enhanced crop Productivity and compatibility through intercropping of sesame and sun Flower Varieties. Annuals of Applied Biology. 2009; 155:285-29
14. Mkamilo GS and Bedigian D. *Sesamum indicum L*. In: Vander Vossen, H.A.M. and Mkamilo GS (Editors). PROTA 14: Vegetable oils/Oléagineux. [CD-Rom]. PROTA, Wageningen, Netherlands; 2007.
15. Alegbejo MD,Iwo GA, Abo ME, and Idowu AA. Sesame : A potential industrial and export oilseed crop in Nigeria Journal of Sustainable Agriculture. 2003; 23(1). The Haworth Press, Inc.
16. Annoymous. Research on sesame improvement. Annual Report. Ayub. Agric Res. Inst., Faisalabad: 60 ;1996.
17. Geleta BM, Atak MA, Baenziger PS, Nelso LA, Baltenesperger DD, Eskridge KM, Shipmam mMJ and Shelton DR . Seeding rate and genotype effects on agronomic performance and end- use quality of winter wheat. Crop Science. 2002; 42: 827-832
18. Adebisi MA, Ariyo OJ and Kehinde OB. Variation and correlation studies in characters in soybean. Ogun J. Agric. Science. 2004; 3 (1): 134-142.
19. Mkamilo GS. Maize-sesame Intercropping in Southerneast Tanzania Farmers Practices and Perceptions, Ph.D. thesis, Wageningen University, Netherlands;2004
20. Agboola AA. Effect of different cropping systems on crop field and soil fertility Management in the Humid .F .A.O. soli bulletin. 1980;43:87105
21. Ofori, F. and Stern W.R. (1986). Maize/cowpea intercrop system: Effect of nitrogen fertilizer on productivity and efficiency. Field Crop Research. 1986; 14: 247-261
22. Fukai S, and Trenbath, BR. Processes Determining Intercrop Productivity and Yield of Component Crop. Field Crop Research.1993;34:237-271
23. Rahman MM, Awal MA, Amim A and Parvej, MP. Compatibility, Growth and Production Potentials of Mustard/ Lentil Intercrops. International. Journal of Botany. 2009; 5:100-106.
24. Baker EFI. Population Time and Crop Mixtures. In: Proceedings of the International workshop Intercropping. International Crop Research Institute for the Semi-arid Tropics (ICRISAT), Education W.Willey,1982; pp.52-60 Hyderabad, India: ICRISAT

25. Trenbath BR. Light Use Efficiency of Crop and potential for Improvement Through Intercropping. Proc. Inter. Workshop on Intercropping 10-13 1979, Hyderabad, India pp.200-215
26. Ofori F and Stern, WR. Cereal-legume Intercropping Systems Advance in Agronomy, 1987; 40:41-90
27. Midmore DJ. Agronomic Modification of Resource Use and Intercrop Productivity. Field Crop Research. 1993; 34: 357-380
28. Enwezor WOE, Udo J and Ajotade KA. Fertilizer Procurement and Distribution. Fertilizer Use and Management Practice for Crops in Nigeria, Savenda Publishers, Nsukka, Nigeria, 1989.
29. Ijoyah MO, and Jimba J.Evaluation of yield and yield components of Maize (Zea mays L.) and okra (Abelmoschus esculentus L. Moench) intercropping system at Makurdi, Nigeria. Journal of Biodiversity and Environmental Sciences. 2012; 2(2), pp. 38–44, 2012.
30. Willey RW. Intercropping – its importance and research needs. Part 1: competition and yield advantages. Field Crop Res. 1979; 32: 1- 10.
31. Adetiloye PO, Ezedinma EOC, Okigbo BN. A land Coefficient Concept for Evaluation of Competitive and Productive Interactions on Simple Complex Mixtures. Economic Modeling. 1983; 19:27-39.
32. De Wit, CT. On competition. Versl. Land Bouwk Onderzoek.1960; 66: 1-82
33. Willey RW, Rao MR. A Competitive Ratio for Qualifying Competition Between Intercrops. Experimental Agriculture. 1980;16:117-125 33
34. Odo PE. Evaluation of short and tall sorghum varieties in mixtures with cow pea in the Sudan savanna of Nigeria: land equivalent ratio, grain yield and system productivity index. Expl. Agric. 1991; 27, 435–441
35. Gomez KA and Gomez AA. Statistical Procedures for Agricultural Research, edn 2, Wiely Interscience Publication and John Willy and Sons, New York, 1984.
36. Iwo GA, AA Idowu and Misary S. Recommendations Registration and Release of Five Sesame(Benniseed) varieties submission to the varietal Release Committee. April 2001 National genetic Res. And Biotech. 2001Moor plantation Ibadan.
37. Umar UA. Effects of herbicides and manual weed control on growth and yield of sesame (Sesamum indicum L.) as Influenced by Nitrogen Fertilizer Level and Intra row Spacing. Msc. Dissertation, faculty of Agriculture. Ahmadu Bello University Zaria, Kaduna State; 2011
38. Mandal BK, Dasgupta S, Roy PK. Effect of Intercropping on Yield Components of wheat Chickpea Mustard under Different Moisture Region. Zitschrift fur acker Und Pflarizenbau India. 1985;155:261-267
39. Enyl BAC. The Effects of Seed Size and Spacing on Growth and Yield in lesser Yam (*Dioscorea esculenta*). Jounal of Agricultural Science. Coiambaore, 1973;78:215-225
40. Fisher NM. Studies in Mixed Cropping II Population Pressure in Maize-beans mixture. Experimental Agriculure.1977;13:188-191
41. Olasatan FO and Lucas EO. Intercropping Maize with Crop of Differing Canopy Height and Similar or differ maturity Using Different Spatial Arrangement. Journal of Agricultural Science and Technology. 1992; 2:13-22.
42. Mann and Jaworski. Minimizing loss of Indole acetic acid during purification of plant extract. Planta. 1970;92:285-281
43. Baker EFI. Population, time and crop mixtures. In: Proceedings of the International Workshop on Intercropping. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), ed. W. Willey, Hyderabad, India: ICRISAT. 1982;52–6
44. Bhatti IH, Ahmad R, Jabbar A, Nazir MS, Mahmood T. Competitive Behaviors of Component Crops in Different Sesame Legume Intercropping Systems. International Journal of Agriculture and Biology. 2006; 165-167.