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Evaluation of the Growth and Yield Performances of Maize in a Soybean Culture in Southeastern Nigeria

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Abstract: *Growth and yield performances of three elite varieties of maize were evaluated in twelve varieties of promiscuous soybean culture for their fertilizer-replacement value in Abakaliki derived sub-humid savanna belt, Southeastern Nigeria on a soil described as Eutric leptosol with pH of 5.18. The composite (Suwan) had the highest mean harvest index (HI) 51% with TGx1844-18E, the hybrid (Oba super II) had 50% with TGx1876-4E, while the local (Ikom white) had 48% with TGx1903-7F and TGx1909-3F. In 2008, TGx1844-4E influenced the highest HI (47%) on Oba super II, TGx1844-18E and TGx1844-4E (46%) on Suwan and TGx1908-8F (45%) on Ikom white, while in 2009, TGx1876-4E had 59% on the hybrid, TGx1904-2F 57% on Suwan and TGx1903-7F 58% on the local which also had the highest mean leaf area index (LAI) of 5.40 with TGx1844-4E and 5.40 in 2008 and 5.38 in 2009, and had a bulky vegetative and late maturing growth rate with the lowest HI of 38%. Few soybean varieties had very significant influence on the growth and yield of these maize varieties, but there were obvious indications that stable sustainable soil fertility and consequently food production can be achieved using a short-duration food legume without external additional fertilizer input.*
Keywords: *Promiscuous soybean, fertilizer-replacement value, elite maize varieties, sustainable soil fertility.*

I. Introduction

Maize is one of the most important cereal crops in the world after wheat and rice and makes the highest demand for nutrients particularly nitrogen (N), deficiency of which limits its production more than other factors as indicated by Wilson and Weir decades ago in 1970. The global maize productivity is 4.92 t/ha, but in Nepal maize yield is 2.35 tons per hectare (t/ha) against the attainable yields of 5.7 t/ha (Gurung et al., 2007), and in neighboring countries; India's average is 2.43 t/ha and the average in Bangladesh is 6.9 t/ha (MoAD, 2013). The productivity of maize in Nepal is constrained primarily by poor access to improved varieties of seed, fertilizer, labour shortage and farmers' lack of awareness about new maize production technologies, as is common in other developing nations of the world. Because maize is such an important food crop for so many millions of food-insecure households throughout Africa, Asia and Latin America, enabling them to achieve greater production from their limited land resources and labour force, should be a priority for agricultural innovation and intensification (SRI-Rice, 2014). This should be contained in the conservation agriculture's underlying principles which hinge on three major areas such as minimal soil disturbance, soil cover and crop rotation which are increasingly recognized as essential for sustainable agriculture.

In Northern Guinea savannah belt of Nigeria, more than 90% of farmers use inorganic fertilizers, but up to 81% of maize farms receive less than half of 120kg N ha^{-1} recommended for maize because of the high cost and inefficient marketing system (Manyong et al., 2001). The maxim "no fertilizer no maize is real" accentuated by the declining production of maize, an indication that maize needs a stable native source of nutrition, a need that is more critical nowadays due to the withdrawal of fertilizer subsidy. NAERLS and APMEU (1996) reported that the land area under maize declined from 2.93 to 2.72 million ha in 1996.

The traditional shifting cultivation known to be ecologically stable and biologically efficient and suitable for the fragile tropical soils with inherent resilience, is no longer feasible, as the fallow periods continued to decrease due to increased pressure on land resulting in reduced crop yields (Glen and Tipper, 2001), demanding a more technical farming system than ever to catch up with population increase and changes in farming environment in terms of food production (Anon, 2004). Patrick et al. (1957), decades ago indicated that cover crops improved soil quality by increasing soil organic matter levels over time thus enhanced soil structure as well as the water and nutrient holding and buffering capacity of soil. The major causes of soil fertility loss is soil erosion as it removes the cream of the soil, reducing its quality by the loss of the nutrient-rich and fertile upper layers of the soil, and reduces its water-holding capacity. Place et al. (2003) observed that the need for accelerated and sustainable agricultural intensification, increased agricultural productivity and improved rural livelihoods under the present population density requires investments in soil fertility maintenance in situ.

Crop agriculture in the face of demographic and environmental threats like soil exhaustion (soil degradation and fertility loss due to over cultivation), human health risks and environmental pollution due to unregulated use of off-farm inputs like fertilizers, pesticides, and energy for food, feed, fibre and bio-energy production (Heffer, 2007; Poudel et al., 2002; NEST, 1991), need to be salvaged. Nearly 2 million hectares worldwide or 22% of all crop lands, pastures, forests and woodlands have been degraded since 1945, 38% has been affected to some degree while more than 6% has been degraded to such an extent that rehabilitation is only possible with large capital investments (Anon, 2003).

Agro-forestry system closely approximates the traditional shifting cultivation/bush fallow system but suffered low acceptance to great many smallholder farmers (Giller, 2003), making ICRAF to refocus her research efforts to more competitive and responsive alternative systems to meet the emerging challenges (Catacutan et al., 2001). Alley cropping can restore soil fertility and increase crop yields and produce additional non-food benefits (Lal.1987; Kang et al., 1990; Hauser and Kang, 1993), but these advantages are often realized only after three or more years which do not augur well with the resource-constrained smallholder farmers. Misiko (2007) therefore observed that the use of research technologies and concepts do improve soil fertility, but their application is generally bolstered when they fulfill indirect benefits (high economic returns and relevant as food, fibre, fodder and fertilizer to pay for their labour and time, beyond simply improving soil fertility) among the resource-deprived smallholder farmers, as labour force dwindles and farm size shrinks. The selection of legume species for inclusion in the nitrogen-fixing leguminosae-nodulating bacteria (NFLNB) technology should therefore be those that are ecologically and economically relevant to the smallholder farmers who use it (Moreira et al., 2009) and who produce much of the developing world’s food and yet are generally much poorer and less food secure than the rest of the population in these countries, even the urban poor. For the foreseeable future, therefore, dealing with poverty and hunger in much of the world means confronting the problem the small-holder farmers and their families face in the daily struggle for survival (Dixon et al., 2001).

Low fertilizer consumption rate can be augmented by the agro-forestry-based soil fertility replenishment technologies, because the tropical soils do not respond well to some of the temperate farming practices that involve the use of fertilizers, herbicides and pesticides (Houngnandan et al., 2000). Intercropping incorporates a multifunctional role in the agro ecosystem, such as resilience to perturbations, protection of plants of individual crop species from their host-specific predators and disease organisms, greater competition towards weeds, improved product quality, reduced negative impact of arable crops on the environment, efficient utilization of growth resources which leads to yield advantages and increased stability compared to sole cropping especially with nitrogen fixing legume inclusion (Andrew and Kassam, 1976). Moreover, literature is scanty on the use of short-duration legumes (soybean) for sustaining growth and yield of heavy nitrogen demanding short-duration non-legume crops like maize. However, literature is rife with researches conducted on the capacity of deep-rooted trees and shrubs and the incorporated prunes to regenerate and recycle soil nutrients for food crop production (Kang et al., 1981, Duguma, 1988, Mittal and Singh, 1989, Lawson and Kang, 1990, Sato and Dalmacio, 1991, Hauser and Kang, 1993). Against this general background, the growth and yield performances of three elite varieties of maize in a culture of twelve promiscuous (naturally nodule-forming) varieties of soybean was studied for two years in southeastern Nigeria to determine the fertilizer replacement value of the soybeans in a sub-humid derived savanna zone of southeastern Nigeria.

II. Materials And Methods

Site description:

The experiment was carried out in 2008 and 2009 cropping seasons on the research farm of Faculty of Agriculture and Natural Resources Management (FARM), Ebonyi State University, Abakaliki, a derived savannah belt of Southeastern Nigeria, lying on latitude 06^0 19´ 407´´ N and longitude 08^o 7´ 831´´ E at an altitude of about 447 m above sea level with mean annual rainfall of about 1700 mm to 2060 mm spread between April and October. The maximum mean daily temperature is between 27^oC to 31^oC with abundant sunshine and a high humidity all through the year. The soil is shallow with unconsolidated parent materials (shale residuum) within 1m of the soil surface, described as Eutric Leptosol (Anikwe et al., 1999). The average soil properties of the research farm are: bulk density- $1.57gcm^{-3}$; total porosity- 41%; pH in water- 5.18; total N- 0.14%; available P- 19.5 ppm, organic carbon- 1.53%; organic matter- 2.64% (obtained by multiplying the organic carbon with a constant 1.724, Odu et al., 1986), extractible Na- 0.06, K- 0.33, Mg- 1.30 and Ca- 2.13 mol kg^{-1} (NRCRI, Umudike analytical laboratory).

Land preparation:

The experimental area was ploughed in June, 2008 and raised-beds manually made and sown with seeds of soybean and maize varieties simultaneously. The same operation was repeated in July, 2009. Two seeds of soybean were sown per hole on six rows at six stands per row, while one seed of maize was sown per stand 25 cm apart on four rows 75 cm apart at four stands per row. Two rows of soybean 30 cm apart were arranged in between two rows of maize, such that soybean row one and row three were 7.5 cm to either rows of maize.

Treatment application:

The experiment was a 12 x 3 factorial arrangement in a randomized complete block design (RCBD) with four replications. Factor A was twelve soybean varieties (six early maturing varieties: TGx 1876-4E, TGx 1485-1D, TGx 1903-7F, TGx 1740-2F, TGx 1904-2F, TGx 1904-4F, and six medium maturing varieties: TGx 1903-5F, TGx 1904-6F, TGx 1908-8F, TGx 1909-3F, TGx 1844-4E and TGx 1844-19E), while factor B was three maize varieties [Suwan (a composite), Oba Supper II (a hybrid) and Ikom white (a local, commonly called farmer's variety)]. This gave 36 treatment combinations or 144 plots of 2.25 m x 1 m size, containing 4 rows of maize at a spacing of 75cm x 25cm and 6 rows of soybean at a spacing of 30 cm x 15 cm. Adjacent to this experimental plot was another trial of the response of the same maize varieties to different soil fertility management practices which could serve the purpose of evaluation of the performance of the soybean culture.

Data collection:

Four stands of plant in the inner rows were taken as observational unit for data collection on the following crop parameters (germination percentage at 5 days after planting (DAP), number of leaves per plant at tasselling, leaf area at tasselling, leaf area index at tasselling, plant height at tasselling (using adjustable metal tape), un-de-husked cob weight per plant after harvest, dehusked cob weight per plant, shelling weight per cob or per plant and 1000 seed weight).

Statistical analysis:

All data collected were subjected to analysis of variance (ANOVA) using a statistical tool, the GenStat model, version 2 (Release 7.22 DE 3) according to Steel and Torrie (1980). Treatment means were separated using Fisher's Least Significant Difference (F-LSD = LSD) as described by Carmer and Swanson (1971) and illustrated by Obi (1986) to identify significant treatment effects in the experiments.

III. Results

The effect of planting maize in a soybean plot on the harvest index (HI) of three maize varieties was significantly ($p<0.05$) improved in 2009 and pooled years but showed no significance in 2008 (Table 1). Oba super II (hybrid) attained its highest HI of 0.59 in 2009 and 0.50 in combined years with TGX 1876-4E, Ikom white (local) with TGx 1903-7F had its highest HI of 0.58 in 2009 and 0.48 in combined years, while Suwan a composite, had its highest HI of 0.57 with TGx 1904-2F in 2009 and 0.51 with TGx1844-18E in combined years. However, the HI of more than 40% achieved by the three maize varieties in 2008 across the soybean varieties was very impressive, though the least HI of 0.36 was obtained in Ikom white with TGX 1844-4E, 0.38 with TGx 1876-4E and 0.39 with TGx1904-6F, TGx 1844-18E and TGx 1903-7F.

The influence of growing three maize varieties in a soybean culture on the de-husked cob weight was significantly different ($p<0.05$) in 2008, 2009 and in the years combined (Table 2). Ikom white had the heaviest de-husked cob weight of 8.78 g with TGx1485-1D, 8.65 g with TGx1844-4E, 7.36 g with TGx1904-6F, 7.06 g with TGx1908-8F, while Oba super II had 7.21 g with TGx1903-7F and Suwan had 6.94 g with TGx1485-1D in 2008. Oba super II with TGx1844-4E and Suwan with TGx1844-18E had the heaviest de-husked cob weight (13.50 g) in 2009, while Ikom white followed with 10.38 g with Tgx1485-1D.

In Table 3 the growing of maize in a soybean culture significantly ($p<0.05$) improved the plant height of the three maize varieties in 2008, 2009 and years combined. The local (Ikom white) appeared to be the tallest plant (208.00 cm with TGx1844-18E) across the soybean varieties in 2008, and in the pooled years, followed by 207.25 cm with TGx1844-4E in 2008 and in pooled years. The shortest recorded plant height of 180.62 cm in the local variety was still taller than the tallest Suwan (composite) and Oba super II (hybrid) maize varieties among the twelve soybean varieties. The tallest Suwan plant (180.25 cm and 179.50 cm) with TGx1909-3F was obtained in 2009 and in 2008 and combined years. Plant height of 179.00 cm and 177.00 cm with TGx1908-8F was obtained in 2009 and in 2008 and combined years. Oba super II achieved the tallest plant height of 153.75 cm with TGx1908-8F, 153.50 cm with TGx19037F and 153.00 cm with TGx1844-4E in 2009.

The effect of intercropping maize with soybean varieties on the leaf area (cm^2) in Table 4 showed that there were significant differences ($p<0.05$) in the three maize varieties used in the experiment in 2008, 2009 and combined years. Ikom white (local) had the largest leaf area of 9997.0 cm^2 with TGx1908-8F, 9932 cm^2 with TGx1844-18E and TGx1844-4E in 2009, 9912.0 cm^2 with TGx1908-8F and 9882.0 cm^2 with TGx1844-18E in 2008 and 9955.0 cm^2 with TGx1908-8F, 9907.0 cm^2 with TGx1844-18E and 9864.0 cm^2 with TGx1903-7F and 9823.0 cm2 with TGx1844-4E and 9822.0 cm^2 with TGx1903-5F in combined years. Oba super II had its largest leaf area of 8693.0 cm^2 with TGx1876-4E in 2009, while Suwan had its largest leaf area of 8958.0 cm^2 with TGx1485-1D in 2009.

Table 5 summarized the intercropping effect of maize varieties and soybean varieties on the leaf area index (LAI) of maize varieties which showed that there were significant ($p<0.05$) differences in the leaf area indices of the three varieties of maize studied. The local (Ikom white) had the largest LAI of 5.38 at TGx1904-

2F, 5.36 at TGx1904-4F in 2009 and also 5.37 in 2008, Suwan had its largest LAI of 4.78 at TGx1485-1D, 4.76 at TGx1844-18E, 4.73 at TGx1908-8F in 2009, while Oba super II had its largest LAI of 4.64 at TGx1876-4E in 2009 and 4.57 at TGx1904-6F in 2008, 2009 and years combined.

In Table 6, the intercropping effect of maize with soybean varieties on the number of leaves of maize showed significant ($p<0.05$) differences on the number of leaves produced by the three varieties of maize in 2008, 2009 and combined years. The local (Ikom white) exceptionally produced the largest number of leaves (15.9) per plant with TGx1485-1D and recorded 14.0 number of leaves per plant with TGx1909-3F, the hybrid maize (Oba super II) produced 13.0 number of leaves per plant consistently, while the composite maize (Suwan) produced 14.0 number of leaves per plant consistently among the soybean varieties in 2008, 2009 and combined years.

The effect of intercropping maize with soybean on the un-de-husked cob weight (g) of maize was significantly different ($p<0.05$) among the three maize varieties in 2008, 2009 and combined years (Table 7). The heaviest un-de-husked cob weight of 25.00 g was obtained in Suwan with TGx1485-1D and in Oba super II (22.69 g) with TGx1844-18E, 22.56 g with TGx1740-2F and 22.31 g with TGx1844-4E in 2009, while the least weight was obtained in Ikom white (10.97 g) with TGx1909-3F in 2008 and combined years.

Table 1: The harvest index (HI) of three maize varieties in a culture of twelve promiscuous soybean varieties

	Year		
Intercrops	2008	2009	Combined
Oba super II +TGx1904-6F	0.45	0.48	0.47
Oba super II +TGx1485-1D	0.44	0.48	0.46
Oba super II +TGx1844-18E	0.43	0.55	0.49
Oba super II +TGx1903-7F	0.45	0.49	0.47
Oba super II +TGx1844-4E	0.47	0.49	0.48
Oba super II +TGx1740-2F	0.43	0.55	0.49
Oba super II +TGx1903-5F	0.42	0.52	0.47
Oba super II +TGx1876-4E	0.42	0.59	0.50
Oba super II +TGx1908-8F	0.44	0.52	0.48
Oba super II +TGx1904-2F	0.44	0.51	0.47
Oba super II+ TGx1909-3F	0.45	0.46	0.45
Oba super II + TGx1904-4F	0.45	0.52	0.49
Suwan +TGx1904-6F	0.42	0.43	0.43
Suwan +TGx1485-1D	0.43	0.51	0.47
Suwan +TGx1844-18E	0.46	0.55	0.51
Suwan +TGx1903-7F	0.45	0.49	0.47
Suwan +TGx1844-4E	0.46	0.51	0.49
Suwan +TGx1740-2F	0.42	0.51	0.47
Suwan +TGx1903-5F	0.43	0.53	0.48
Suwan +TGx1876-4E	0.42	0.50	0.46
Suwan +TGx1908-8F	0.43	0.51	0.47
Suwan +TGx1904-2F	0.43	0.57	0.50
Suwan +TGx1909-3F	0.44	0.54	0.49
Suwan +TGx1904-4F	0.42	0.51	0.46
Ikom +TGx1904-6F	0.39	0.52	0.46
Ikom +TGx1485-1D	0.41	0.47	0.44
Ikom +TGx1844-18E	0.39	0.42	0.40
Ikom +TGx1903-7F	0.39	0.58	0.48
Ikom +TGx1844-4E	0.36	0.47	0.42
Ikom +TGx1740-2F	0.40	0.48	0.44
Ikom +TGx1903-5F	0.42	0.48	0.45
Ikom +TGx1876-4E	0.38	0.50	0.44
Ikom +TGx1908-8F	0.45	0.48	0.47
Ikom +TGx1904-2F	0.40	0.42	0.41
Ikom +TGx1909-3F	0.44	0.51	0.48
Ikom +TGx1904-4F	0.41	0.47	0.44
F-LSD (P=0.05)	0.06	0.06	0.05

Table 2: The de-husked cob weight of three maize varieties (g plant^{-1}) in a culture of twelve promiscuous soybean varieties

	Year		
Intercrops	2008	2009	Combined
Oba super II TGx1904-6F	5.63	11.88	8.75
Oba super II TGx1485-1D	6.75	11.75	9.25
Oba super II TGx1844-18E	5.69	11.56	8.63
Oba super II TGx1903-7F	7.21	13.31	10.31
Oba super II TGx1844-4E	6.75	13.50	10.13
Oba super II TGx1740-2F	6.00	12.23	9.11
Oba super II TGx1903-5F	6.00	11.69	8.84
Oba super II TGx1876-4E	5.44	9.69	7.81
Oba super II TGx1908-8F	5.13	11.75	8.44
Oba super II TGx1904-2F	6.06	9.94	8.50
Oba super II TGx1909-3F	5.63	11.56	8.59
Oba super II TGx1904-4F	5.94	8.83	7.38
Suwan +TGx1904-6F	5.88	11.25	8.56
Suwan +TGx1485-1D	6.94	13.25	10.09
Suwan +TGx1844-18E	6.38	13.50	9.94
Suwan +TGx1903-7F	6.44	10.75	8.59
Suwan +TGx1844-4E	5.75	11.38	8.56
Suwan +TGx1740-2F	5.75	11.75	8.75
Suwan +TGx1903-5F	6.19	11.31	8.75
Suwan +TGx1876-4E	5.69	11.25	8.47
Suwan +TGx1908-8F	5.25	12.31	8.78
Suwan +TGx1904-2F	5.00	8.25	6.63
Suwan +TGx1909-3F	4.75	10.19	7.47
Suwan +TGx1904-4F	6.00	9.44	7.72
Ikom +TGx1904-6F	7.36	8.81	8.09
Ikom +TGx1485-1D	8.78	10.38	9.58
Ikom +TGx1844-18E	5.25	7.94	6.59
Ikom +TGx1903-7F	6.31	8.25	7.28
Ikom +TGx1844-4E	8.65	8.25	8.45
Ikom +TGx1740-2F	5.31	8.75	7.03
Ikom +TGx1903-5F	6.17	8.63	7.40
Ikom +TGx1876-4E	5.81	7.13	6.47
Ikom +TGx1908-8F	7.06	7.19	7.13
Ikom +TGx1904-2F	4.95	6.88	5.91
Ikom +TGx1909-3F	4.81	6.78	5.79
Ikom +TGx1904-4F	5.31	7.94	6.63
F-LSD (P=0.05) =	2.77	1.70	1.37

Table 3**:** The plant height (cm) of three maize varieties of twelve promiscuous soybean varieties

	Year		
Intercrops	2008	2009	Combined
Oba super II TGx1904-6F	152.75	152.75	152.75
Oba super II TGx1485-1D	152.38	151.25	152.38
Oba super II TGx1844-18E	152.50	152.00	152.50
Oba super II TGx1903-7F	152.75	153.50	152.75
Oba super II TGx1844-4E	152.50	153.00	152.75
Oba super II TGx1740-2F	152.12	151.25	152.12
Oba super II TGx1903-5F	152.62	152.00	151.62
Oba super II TGx1876-4E	152.88	152.25	151.88
Oba super II TGx1908-8F	152.12	153.75	152.12
Oba super II TGx1904-2F	152.12	151.25	152.12
Oba super II TGx1909-3F	152.75	150.50	151.75
Oba super II TGx1904-4F	152.50	151.00	152.50
Suwan +TGx1904-6F	167.62	174.00	167.62
Suwan +TGx1485-1D	169.88	164.50	169.88
Suwan +TGx1844-18E	175.62	175.75	175.62
Suwan +TGx1903-7F	175.38	176.25	175.38
Suwan +TGx1844-4E	177.25	176.50	177.25
Suwan +TGx1740-2F	175.62	176.25	175.62
Suwan +TGx1903-5F	175.62	173.25	175.62
Suwan +TGx1876-4E	172.38	175.00	172.38
Suwan +TGx1908-8F	177.00	179.00	177.00
Suwan +TGx1904-2F	171.75	165.50	171.75
Suwan +TGx1909-3F	179.50	180.25	179.50
Suwan +TGx1904-4F	175.25	177.00	175.25
Ikom +TGx1904-6F	199.75	199.25	199.75
Ikom +TGx1485-1D	200.12	202.25	200.12
Ikom +TGx1844-18E	208.00	205.50	208.00

Ikom +TGx1903-7F	203.00	203.25	203.00
Ikom +TGx1844-4E	207.25	205.25	207.25
Ikom +TGx1740-2F	203.00	202.50	203.00
Ikom +TGx1903-5F	203.75	203.25	203.75
Ikom +TGx1876-4E	202.25	200.00	202.25
Ikom +TGx1908-8F	204.25	204.00	204.25
Ikom +TGx1904-2F	180.62	207.50	180.62
Ikom +TGx1909-3F	201.75	200.25	201.75
Ikom +TGx1904-4F	204.12	203.50	204.12
F-LSD (P=0.05) =	12.15	8.55	11.86

Table 4: The leaf area (cm^2) of three maize varieties in a culture of twelve promiscuous soybean varieties

	Year		
Intercrops	2008	2009	Combined
Oba super II TGx1904-6F	8574.0	8574.0	8574.0
Oba super II TGx1485-1D	8096.0	8222.0	8159.0
Oba super II TGx1844-18E	8194.0	8112.0	8153.0
Oba super II TGx1903-7F	8030.0	7949.0	7990.0
Oba super II TGx1844-4E	7757.0	8277.0	8017.0
Oba super II TGx1740-2F	8010.0	8036.0	8023.0
Oba super II TGx1903-5F	8209.0	8195.0	8202.0
Oba super II TGx1876-4E	8221.0	8693.0	8457.0
Oba super II TGx1908-8F	8031.0	8379.0	8205.0
Oba super II TGx1904-2F	7884.0	7910.0	7897.0
Oba super II TGx1909-3F	8116.0	7931.0	8024.0
Oba super II TGx1904-4F	8118.0	7858.0	7988.0
Suwan +TGx1904-6F	8597.0	8482.0	8540.0
Suwan +TGx1485-1D	8847.0	8958.0	8903.0
Suwan +TGx1844-18E	8692.0	8875.0	8784.0
Suwan +TGx1903-7F	8381.0	8558.0	8470.0
Suwan +TGx1844-4E	8405.0	8517.0	8461.0
Suwan +TGx1740-2F	8417.0	8419.0	8418.0
Suwan +TGx1903-5F	8224.0	8579.0	8402.0
Suwan +TGx1876-4E	8357.0	8392.0	8525.0
Suwan +TGx1908-8F	8638.0	8870.0	8754.0
Suwan +TGx1904-2F	8619.0	8619.0	8619.0
Suwan +TGx1909-3F	8752.0	8752.0	8752.0
Suwan +TGx1904-4F	8708.0	8740.0	8724.0
Ikom +TGx1904-6F	9758.0	9758.0	97580
Ikom +TGx1485-1D	9492.0	9522.0	9507.0
Ikom +TGx1844-18E	9882.0	9932.0	9907.0
Ikom +TGx1903-7F	9827.0	9901.0	9864.0
Ikom +TGx1844-4E	9713.0	9932.0	9823.0
Ikom +TGx1740-2F	9652.0	9482.0	9567.0
Ikom +TGx1903-5F	9822.0	9822.0	9822.0
Ikom +TGx1876-4E	9487.0	9337.0	9412.0
Ikom +TGx1908-8F	9912.0	9997.0	9955.0
Ikom +TGx1904-2F	9786.0	9786.0	9786.0
Ikom +TGx1909-3F	9360.0	9337.0	9349.0
Ikom +TGx1904-4F	9363.0	9632.0	9498.0
F-LSD (P=0.05) =	537.7		536.8

Table 5: The leaf area index (LAI) of three maize varieties in a culture of twelve promiscuous soybean varieties

	Year		
Intercrops	2008	2009	Combined
Oba super II TGx1904-6F	4.57	4.57	4.57
Oba super II TGx1485-1D	4.31	4.39	4.31
Oba super II TGx1844-18E	4.37	4.33	4.37
Oba super II TGx1903-7F	4.28	4.24	4.28
Oba super II TGx1844-4E	4.14	4.42	4.14
Oba super II TGx1740-2F	4.27	4.29	4.27
Oba super II TGx1903-5F	4.38	4.37	4.38
Oba super II TGx1876-4E	4.39	4.64	4.39
Oba super II TGx1908-8F	4.35	4.47	4.35
Oba super II TGx1904-2F	4.21	4.22	4.21
Oba super II TGx1909-3F	4.33	4.23	4.33
Oba super II TGx1904-4F	4.33	4.19	4.33
Suwan +TGx1904-6F	4.59	4.53	4.59
Suwan +TGx1485-1D	4.72	4.78	4.72
Suwan +TGx1844-18E	4.65	4.76	4.70
Suwan +TGx1903-7F	4.47	4.57	4.52
Suwan +TGx1844-4E	4.49	4.55	4.52
Suwan +TGx1740-2F	4.49	4.49	4.49
Suwan +TGx1903-5F	4.57	4.37	4.47
Suwan +TGx1876-4E	4.46	4.49	4.48
Suwan +TGx1908-8F	4.61	4.73	4.67
Suwan +TGx1904-2F	4.59	4.52	4.56
Suwan +TGx1909-3F	4.67	4.62	4.65
Suwan +TGx1904-4F	4.65	4.66	4.66
Ikom +TGx1904-6F	5.14	5.33	5.24
Ikom +TGx1485-1D	5.06	5.08	5.07
Ikom +TGx1844-18E	5.39	5.30	5.35
Ikom +TGx1903-7F	5.28	5.24	5.26
Ikom +TGx1844-4E	5.40	5.40	5.40
Ikom +TGx1740-2F	5.28	5.32	5.30
Ikom +TGx1903-5F	5.32	5.24	5.28
Ikom +TGx1876-4E	5.06	4.98	5.02
Ikom +TGx1908-8F	5.29	5.33	5.31
Ikom +TGx1904-2F	5.23	5.38	5.30
Ikom +TGx1909-3F	4.99	4.98	4.99
Ikom +TGx1904-4F	5.37	5.36	5.37
F-LSD (P=0.05) =	0.29	0.40	0.29

Table 6: The number of leaves of three maize varieties in a culture of twelve promiscuous soybean varieties

	Year		
Intercrops	2008	2009	Combined
Oba super II TGx1904-6F	13.0	13.0	13.0
Oba super II TGx1485-1D	13.1	13.3	13.1
Oba super II TGx1844-18E	13.3	13.3	13.3
Oba super II TGx1903-7F	13.0	13.0	13.0
Oba super II TGx1844-4E	12.8	12.8	12.8
Oba super II TGx1740-2F	13.0	13.0	13.0
Oba super II TGx1903-5F	13.3	13.3	13.3
Oba super II TGx1876-4E	13.4	13.4	13.4
Oba super II TGx1908-8F	12.8	12.8	12.8
Oba super II TGx1904-2F	13.0	13.0	13.0
Oba super II TGx1909-3F	13.3	13.3	13.3
Oba super II TGx1904-4F	13.3	13.3	13.3
Suwan +TGx1904-6F	14.0	14.0	14.0
Suwan +TGx1485-1D	14.3	14.3	14.3
Suwan +TGx1844-18E	14.0	14.0	14.0
Suwan +TGx1903-7F	14.0	14. 0	14.0
Suwan +TGx1844-4E	14.0	14. 0	14.0
Suwan +TGx1740-2F	14.0	14. 0	14.0
Suwan +TGx1903-5F	14.1	14. 0	14.1
Suwan +TGx1876-4E	14.0	14.0	14.0
Suwan +TGx1908-8F	14.1	14.3	14.1
Suwan +TGx1904-2F	14.1	14.0	14.1
Suwan +TGx1909-3F	14.1	14.0	14.1
Suwan +TGx1904-4F	14.1	14.5	14.1

Ikom +TGx1904-6F	15.1	15.3	15.1
Ikom +TGx1485-1D	15.9	15.9	15.9
Ikom +TGx1844-18E	15.3	15.3	14.9
Ikom +TGx1903-7F	15.0	15.0	15.3
Ikom +TGx1844-4E	15.1	15.3	15.0
Ikom +TGx1740-2F	15.4	15.0	15.4
Ikom +TGx1903-5F	15.0	15. 0	15.0
Ikom +TGx1876-4E	15.1	15. 0	15.1
Ikom +TGx1908-8F	15.1	15. 0	15.0
Ikom +TGx1904-2F	15.0	15. 0	15.0
Ikom +TGx1909-3F	14.0	14. 0	14.0
Ikom +TGx1904-4F	15.1	15. 0	15.1
F-LSD (P=0.05) =	0.37	0.48	0.40

Table 7: The un-de-husked cob weight (g) of three maize varieties in a culture of twelve promiscuous soybean varieties

	Year		
Intercrops		2009	Combined
Oba super II TGx1904-6F	15.94	20.62	15.94
Oba super II TGx1485-1D	16.00	19.38	16.00
Oba super II TGx1844-18E	16.72	22.69	16.72
Oba super II TGx1903-7F	17.81	21.62	17.81
Oba super II TGx1844-4E	17.72	22.31	17.72
Oba super II TGx1740-2F	17.06	22.56	17.06
Oba super II TGx1903-5F	15.94	20.62	15.94
Oba super II TGx1876-4E	14.06	16.88	14.06
Oba super II TGx1908-8F	15.22	20.88	15.22
Oba super II TGx1904-2F	14.54	18.00	14.54
Oba super II TGx1909-3F	14.81	19.12	14.81
Oba super II TGx1904-4F	13.94	16.81	13.94
Suwan +TGx1904-6F	15.53	20.00	15.53
Suwan +TGx1485-1D	19.06	25.00	19.06
Suwan +TGx1844-18E	17.16	22.50	17.16
Suwan +TGx1903-7F	15.22	18.81	15.22
Suwan +TGx1844-4E	14.91	19.38	14.91
Suwan +TGx1740-2F	16.16	21.44	16.16
Suwan +TGx1903-5F	15.81	20.19	15.81
Suwan +TGx1876-4E	15.88	21.50	15.88
Suwan +TGx1908-8F	16.16	22.44	16.16
Suwan +TGx1904-2F	12.66	15.94	12.66
Suwan +TGx1909-3F	13.81	18.88	13.81
Suwan +TGx1904-4F	14.13	17.50	14.13
Ikom +TGx1904-6F	15.78	17.25	15.78
Ikom +TGx1485-1D	18.19	1931	18.19
Ikom +TGx1844-18E	12.69	15.56	12.69
Ikom +TGx1903-7F	14.26	16.25	14.26
Ikom +TGx1844-4E	16.31	15.75	16.31
Ikom +TGx1740-2F	13.34	16.50	13.34
Ikom +TGx1903-5F	14.40	17.38	14.40
Ikom +TGx1876-4E	12.78	14.62	12.78
Ikom +TGx1908-8F	13.81	13.94	13.81
Ikom +TGx1904-2F	11.69	13.88	11.69
Ikom +TGx1909-3F	10.97	12.38	10.97
Ikom +TGx1904-4F	12.38	14.88	12.38
F-LSD (P=0.05) =	4.76	2.64	2.39

IV. Discussion

Growing three maize varieties in a culture of twelve soybean varieties in the absence of inorganic fertilizer for two years proved that all the parameters of growth and yield measured performed optimally without serious hampering of the expression of their genetic make-up. On that note, it was obvious that in 2009, there was a significant improvement in HI of maize than in 2008 in which the three maize varieties attained a HI of up to 50% and above. This result shows that some soybean varieties had greater residual influence on the dry matter distribution among the maize varieties than other soybean varieties. The result could also showcase soybean plants as having residual benefits on non-legume intercrops like maize in that no maize variety attained up to 50% dry matter distribution in 2008, but only in the subsequent year. This positive effect of intercropping maize with soybean shows that maize growth and yield parameters can be supported in an intercropping culture with soybean without much impairment on what is expected in a conventional inorganic fertilizer programme, thereby evidently demonstrating the high fertilizer replacement value (FRV) of soybean to a non legume companion. There was also that advantage of improved yield in subsequent seasons as evidenced in the second year of the experiment to sufficiently prove the argument whether soybean as a soil fertility crop has current beneficial effect to a companion non-legume crop as well as residual effect worthwhile.

Arnon (1972) reported that for food crop production, intercropping is frequently used and the system varies from locality to locality depending on the farmer's total resources. Smallholder farmers routinely intercrop cereal staple crops (maize, sorghum, millets, etc.) with vegetable crops (pumpkin, squash, gourd, cucumber and water melon) and legumes (beans, cowpea and groundnuts) because of their ability to regenerate nutrients. On the other hand, Smith (2006) had expressed one of the several beneficial symbiotic relationships between legumes and cereals in an intercropping system without any bioterrorism on one another. This symbiotic relationship was highlighted by Giller and Dashiell (2007) when they stated that soybean helps maize overcome the scourge of Witch weed (Striga species) which has ravaged maize farms in the Northern parts of Nigeria.

The de-husked cob weight of maize is suggested to be a good yield index with shelling weight or 1000 seed weight on which yield indices could be based and Ikom white is expected to produce this heaviest result because its cob is usually larger than Suwan (a composite) and Oba super II (a hybrid) and even the whole plant appears to be a giant plant in comparison with the two, but why it could not sustain that performance in 2009 is not easily explained with the results. Oba super II and Suwan varieties of maize performed exceptionally better than Ikom white in 2009 among the twelve varieties of soybeans in terms of the de-husked cob weight. This observation is expected because of the compact nature of the cob husk as against the corky nature of the Ikom white cob husk. At 14% moisture content of maize de-husked cob weight, Oba super II and Suwan appeared to be heavier than the local. Obi (2006) stated that 1000 seed weight measurement detects the food energy production of the grain which he claims is higher in maize than rice and wheat.

It was observed that the supposedly significant difference in the vegetative parameters was among the three maize varieties due to their genetic make-up as the local variety tends to grow taller and heavier than the other two breeds, and partly due to intercropping effect within the varieties as can be explained by the improved vegetative growth with some soybean varieties. Consequently, some soybean varieties appeared to have influenced the plant height, number of leaves, LAI and leaf area of maize in some isolated cases, and these can be used as strong evidence to emphasis significant effect of intercropping on the growth parameters.

V. Conclusion

Maize production can be sustained, soil fertility improved, soil degradation halted, crop production intensified and livelihoods improved through the judicious use of legume crops especially the pulses like soybean among the resource-constrained smallholder farmers in this agro-ecological zone. Agro-forestry/bush fallow systems closely approximate the traditional shifting cultivation benefits known to be ecologically stable and biologically efficient and resilience for the fragile tropical soils, albeit, despite its numerous advantages, it has no direct commensurate food supply to the farmers for all their labours. Population growth and the need to feed the hungry mouths and its pressure on arable lands for more food production and other non-agricultural needs has nullified the merits of the bush fallow system, which underscores the importance of this study.

Intercropping maize and soybean insures the smallholder farmers against soil fertility loss, starvation and hidden hunger and is highly recommended for the resource-constrained smallholder farmers in this zone amidst the global climate change.

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