Influence of N Starter Dose on Yield and N-uptake of two Soyabean varieties in Southern Guinea Savanna of Nigeria, West Africa

[1]Oyatokun Olukayode Stephen, [2]Adeoye Gideon Olajire and [3]Oluwasemire Kolapo Olatunji
[1,2 & 3]Department of Agronomy, University of Ibadan
Correspondence: steveoyatokun@yahoo.com
08033518801

Accepted on June 30, 2013

Abstract
Nitrogen is one of the major nutrient elements of soyabean and is the most-limiting factor for its production after moisture in sub-sahara Africa. Its source could be organic or inorganic. Two parallel field experiments were conducted during 2010 planting season to evaluate the influence of Nitrogen (N) starter dose on two soyabean varieties in southern guinea savanna agro-ecology zone of Nigeria. The objectives were to assess N dose that synergies yield across the two varieties and to evaluate N-assimilation of the two varieties under varying N starter dose. The experiments were set up in a 5x2x3 split-plot fitted into randomized complete block design, where N doses of 0 (control), 5, 15, 25 and 35 kg N/ha applied in the form of urea a week after planting were at the main plot and soyabean varieties: TGx1485-1D and TGx1448-2E were at the sub-plot with three replications. All plants located in a well surrounded pre-selected final harvest area of 750cm²/subplot were selected at maturity for the evaluation of biomass yield. The pods were threshed and grains dried to determine 100 seed weight, seed yield and harvest index. There was a significant difference ($p<0.05$) in varietal response to some traits measured. While TGx1448-2E produced a significantly higher 100 seed weight of 27.28g, TGx1485-1D produced 100 seed weight of 21.73g. Also TGx1448-2E had a significantly higher plant dry biomass (7.363t/ha) than TGx1485-1D (4.673t/ha) and these could be due to genotypic superiority of TGx1448-2E to TGx1485-1D. However, the application of N starter-dose was found to have less effect on the yield and N-uptake of soyabean within individual varieties investigated in the region. This was attributed to high rainfall regime during the growing season which might have led to leaching-loss of the applied N. This is a merit for organic agriculture which excludes environmental pollution that the mineral fertilizer caused in this investigation.

***Keywords**: Southern guinea savanna, N – uptake, agro-ecology, Soyabean, N-assimilation.*

Introduction

Soyabean (*Glycine max* L. Merril) is an evolving major food as well as an industrial crop in Nigeria (Brader, 1998). Its production is rapidly taking a centre place among cereals and grain legume production in the moist savanna zone of Nigeria. Nitrogen (N) is one of the most important nutrient elements of soyabean (Penas and Wiese, 1987) and is the most limiting factor to its production after moisture in the sub-Sahara Africa. The N requirement of soyabean is typically met by a combination of soil-derived nitrogen and nitrogen provided through the process of symbiotic fixation from rhizobia bacteria in root nodules (Sanginga *et al.*, 2001). The relative supply from these two sources can change widely depending on soil nitrogen supply and conditions for nodule development (Gan *et al.*, 2003).

Although nitrogen fertilization of soyabean is not a common practice as it is believed that soyabean, like all leguminous plants, has the ability to fix N for its use but the fixed N may not be adequate for maximum yield. For a legume to effectively carry out the process of biological nitrogen fixation (BNF), it must be properly established especially if such legume is high yielding and efficient in BNF (Okogun *et al.*, 2005).

Numerous field studies have shown inconsistencies in the recommendations in the requirement for this starter N at the early growth stage of grain legumes (Tanimu and Yayock, 1990; Jefing *et al.*, 1992; Taylor *et al.*, 2005), thereby leading to a dearth of information on the required suitable N rate that synergies early establishment to improve soyabean N-uptake and grain yield. Higher N application to crops especially might be leached to pollute underground water or surface water that leads to eutrophication.

Thus this study assess the influence of N starter dose on yield of two widely cultivated soyabean varieties in the southern guinea savanna agro-ecological zone of Nigeria with the aim of proffering sustainable N management practices.

Materials and Methods

The experiments were conducted at Ipapo (Latitude 8° 08' N; Longitude 03° 30' E) and Gbonran (Latitude 8° 06' N; Longitude 03° 30' E) in Oyo North which lies within the Southern Guinea Savanna agro-ecology.

The mean annual rainfall of the area varies from 1000mm – 1400mm. Most of the rainfall is concentrated between April and October and the wet and dry seasons are usually well marked. In August, there is a short dry season in between the rainy months. Temperatures are usually high throughout the year with an annual mean of 27°C. Relative humidity is high and varies from 60 – 80%.

The rocks underlying 95% of the area are ancient crystalline basement complex formations which are generally acidic in composition. The basement complex consists mainly of gneiss, schist, quartzite, magmatite and marble but locally granite or syenite and intrusions of amphibolites and olivine-rich dykes are found. Basement complex rocks give rise to a wide variety of soils. According to FAO world soil map, luvisols are the most prevalent (about 70%). Also, arenosols, fluvisols, lithosols and nitosols are found. Most of the soils change in texture with depth, and have sandy topsoil over subsoil with higher clay content. Acidity increases with depth but never reaches extreme values. Iron concretions and quartz gravels are common features of the soils.

The land-use over time was for arable farming where maize and cassava were the major crops. Natural fallow was the means of land regeneration and the field had not been planted to soyabean or any legume in the past 55 years. However, nomads usually graze their cattle on the fields during the fallow periods.

Characteristics of soyabean varieties.

Two promiscuous soyabean varieties TGx 1448 – 2E and TGx 1485 – 1D were planted in the course of this study. Variety TGx 1448 – 2E is a late maturing cultivar, it matures about 105-110 days after planting while TGx 1485 - 1D is an early to medium maturing type which matures about 90-100 days after planting. The 2 varieties are very efficient in nitrogen fixation (IITA 1984).

Meterological Data

Daily data for precipitation, evapo-transpiration, minimum and maximum temperatures were collected from the observation station of the National Meteorological Agency, Iseyin Zonal Office (NIMET) which is at a distance of about 5-10km to the two fields. Monthly and annual totals were computed for precipitation and evapo-transpiration while the mean monthly temperature values were computed as

$[\sum (Dmax+Dmin/2)]/Ndays.$

Where Dmax= Daily maximum temperature

Dmin= Daily minimum temperature

Ndays =Number of days in the specific month

Soil Analysis/sampling

Top soil samples (0-15cm) from the two locations were collected separately, air dried and sieved to pass through 2mm-sieve for pre-planting routine soil analysis.

Experimental procedures and design

A total land area of 560 sq. meters was allocated for the field trial. The land was cleared, marked and pegged into 5m x 4.5m (22.5 sq. m) which is the size of an experimental plot. The land was divided into five (5) small plots with three replications. Oba 98 maize hybrid (quality maize with high nitrogen requirements) was used to mop up the native nitrogen and was uprooted when a sign of N deficiency was noticed.

Planting of soyabean seeds was done on the 11^{th} June 2010 with a planting distance of 75cm x 5cm, 1 soyabean seed/hole (due to shortage of seeds), 3-4cm deep to give a total plant population of 266,667 plants per hectare. Weeding was done by hoeing once before canopy establishment.

The experiment was laid out as a 5 x 2 x 3 split-plot in a randomized complete block design. N application dose of 0 (control), 5 , 15, 25 and 35 kg N/ha is at the main plot while soyabean varieties TGx 1485-1D and TGx 1448-2E are at the sub-plot with three replications. Starter N was applied in the form of Urea by banding 1WAP. Parameters measured are leaf weight, stem weight, % shoot N, weight of 100 seeds and harvest index.
Data obtained were subjected to analysis of variance procedures using GENSTAT discovery edition 3. Means were separated with least significant difference (LSD) at 5% probability level (Steel and Torrie, 1987). Descriptive statistics were also used to describe trend and pattern of parameters.

Results and discussion

Meteorological parameters

The annual rainfall was 1475.8mm and potential evapo-transpiration was 1676.8mm (Table 1).

Table 1: Monthly rainfall and potential evapotranspitarion for Gbonran and Ipapo, 2010

Month	Rainfall (mm)	Potential Evapotranspiration (mm)	Mean monthly Temperatures (°C)
Jan	0.0	170.2	28.7
Feb	19.5	168.2	29.8
Mar	131.6	169.9	29.1
Apr	43.5	149.8	28.9
May	204.4	128.2	27.1
Jun	167.4	115.3	26.7
Jul	105.3	108.5	24.9
Aug	205.7	110.9	24.8
Sep	256.5	120.8	25.4
Oct	240.5	136.5	25.9
Nov	101.4	138.5	26.8
Dec	0.0	160.0	27.1
Total/Mean	**1475.8**	**1676.8**	**27.1**

Source: NIMET, Iseyin zonal office (2010)

This implies an annual moisture deficit of 201mm was recorded in the 2010. This deficit was however encountered for five months which are regarded as the dry season in the region. The mean monthly temperature in the study period were all within the 20-30°C which is the recommended optimum temperature range for soyabean production. Figure 1 presents the total monthly rainfall against half potential evapo-transpiration. The planting season in the study area starts around May and it stabilizes in June. This is given by the fact that the rainfall values are above the half potential evapo-transpiration as described by Oluwasemire *et al.*, (2002).

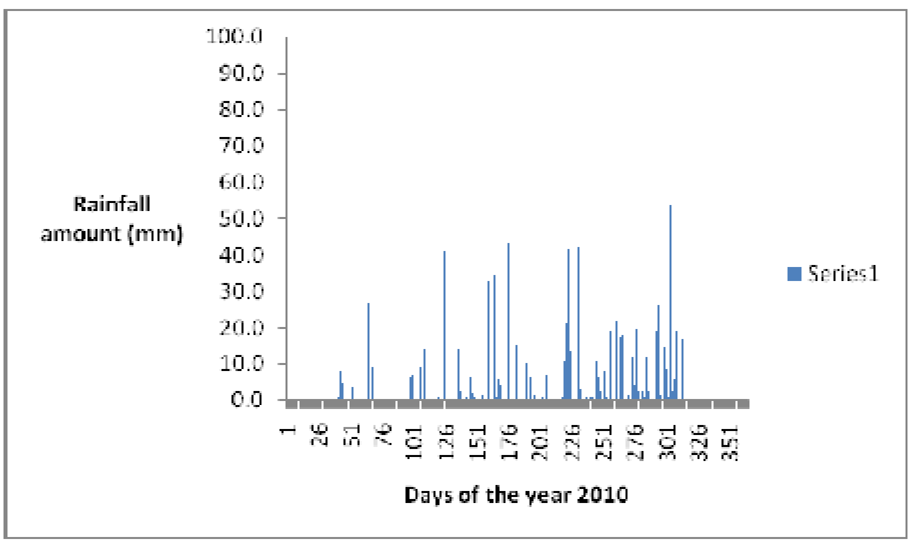

Figure 1: Showing daily rainfall distribution for Gbonran and Ipapo 2010
Source: NIMET Iseyin Zonal Office (2010)

More still, the daily distribution of precipitation displayed in Figure 2 shows high concentration of rain in the months of June, July, September and October which might have led to high rate of leaching and soil erosion during these months.

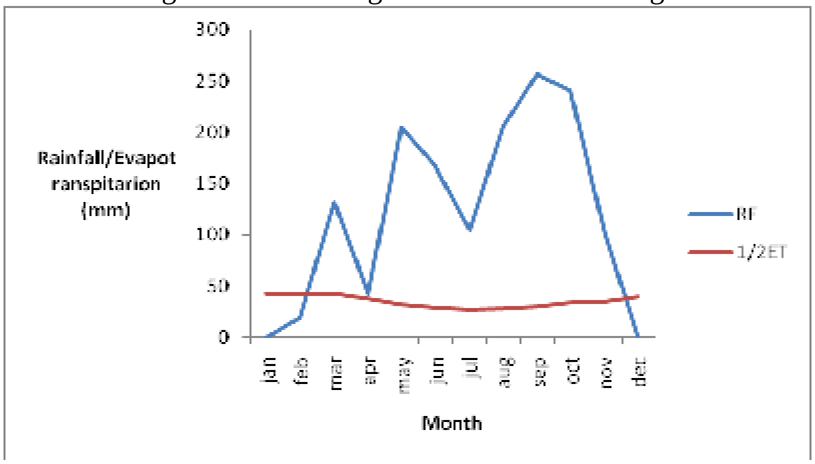

Figure 2: Graph showing monthly rainfall vs half potential evapotranspiration for Gbonran and Ipapo 2010.
Source: NIMET Iseyin Zonal Office (2010).

Soil properties
Some of the physico-chemical properties of the soil in both fields are pH 6.4 showing that the soils are slightly acidic, which is within the optimum range of 5.8 to 7.0 recommended for soyabean (NebGuide, 2006), total Nitrogen (g/kg) – 0.7 and 1.0; organic Carbon (g/kg) 8.6 and 12.1; available P (mg/kg) 6.3. and 7.3, and K (cmol/kg) 0.2 apiece for Ipapo and Gbonran respectively in Table 2.

Table 2: Some physico-chemical properties of the soil

Parameter		**Ipapo**	**Gbonran**
pH(H2O)		6.4	6.4
TN	g/kg	0.7	1.0
Org C	g/kg	8.6	12.1
Mehlic P	mg/kg	6.3	7.3
Ca	c mol/kg	1.3	1.9
Mg	"	1.1	1.2
K	"	0.2	0.2
Na	"	0.3	0.3
Exch Acid.	"	0.2	0.3
Fe	mg/kg	27.0	29.8
Mn	"	98.2	130.3
Cu	"	2.1	2.6
Zn	"	1.3	1.5
Particle size (g/kg)			
Clay		48	68
Silt		80	120
Sand		872	812
Textural class		Loamy Sand	

This showed that the soils in both locations are inherently low in fertility. The total N, available P and K were very low and the organic matter content was also low to hold nutrients. The soil textural class is loamy sand.

Weight of 100 seeds

This is an important yield contributing component. It reflects the magnitude of seed development which ultimately reflects the final yield of the crop.

In Gbonran field, soyabean responded differently to N doses in terms of weight of 100 seeds (Table 4). The relationship between seed weight and N doses was inverse while 0 kg N/ha (control treatment) produced the heaviest 100 seeds, 35 kg N/ha dose produced the lightest 100 seeds. This showed that N application favoured vegetative growth and by extension hindered seed yield. This result was in agreement with the work of Mehmet (2008) which showed that as N level increases, there was decrease in weight of 100 seeds. There was also a significant difference in varietal response to 100 seed weight in Ipapo field (Table 3) with TGx1448-2E producing heavier 100 seeds (23.90g) than TGx1485-1D (16.67g).

However, there was no marked difference in the response of soyabean to N starter doses in terms of weight of 100 seeds in Ipapo field.

Table 3: Effects of N Dose and Variety on Yield and N-uptake in Ipapo

Treatment	100 seed wt (g)	%Shoot N	Plant Dry wt (kg/ha)	Seed Dry wt (kg/ha)	Harvest Index
			Nitrogen Dose		
0 kg N/ha	24.72	3.045	4702	1067b	0.227c
5 kg N/ha	23.18	2.771	4216	1994ab	0.473a
15 kg N/ha	23.97	3.171	7439	2931a	0.394ab
25 kg N/ha	24.90	2.748	7104	3161a	0.445ab
35 kg N/ha	25.75	2.896	6628	2022ab	0.305bc
LSD (0.05)	4.11 ns	0.480 ns	3139 ns	1181.5	0.1571
			Soyabean variety		
1485-1D	21.73b	3.289a	4673b	1779b	0.509a
1448-2E	27.28a	2.564b	7363a	2691a	0.228b
LSD (0.05)	2.75	0.42	2096.2	747.2	0.099

Means followed by the same letter are not significantly different at $p < 0.05$
ns – not significant

Percentage N accumulation in the shoot

The two soyabean varieties showed a significantly different response in terms of N accumulation in Ipapo field where TGx 1485-1D had a greater N accumulation (3.29%) in shoot than TGx 1448-2E (2.56%) and showed no significance in Gbonran field. However, response to N starter dose in terms of shoot N accumulation was similar across both locations (Tables 3 and 4).

Table 4: Effects of N Dose and Variety on Yield and N-uptake in Gbonran

Treatment	100 seed wt (g)	%Shoot N	Plant Dry wt (kg/ha)	Seed Dry wt (kg/ha)	Harvest Index
			Nitrogen Dose		
0 kg N/ha	22.29a	2.91	6050	2293	0.379
5 kg N/ha	19.87b	2.56	3915	1484	0.379
15 kg N/ha	19.62b	2.89	5036	2236	0.444
25 kg N/ha	20.00b	2.33	8125	2868	0.353
35 kg N/ha	19.62b	2.78	6129	2102	0.343
LSD (0.05)	1.67	0.94 ns	5239 ns	1797 ns	0.121 ns
			Soya bean variety		
1485-1D	16.67b	2.81	2692b	1008b	0.484a
1448-2E	23.90a	2.57	9010a	3386a	0.275b
LSD (0.05)	1.48	0.43 ns	2934.9	1136.9	0.0767

Means followed by the same letter are not significantly different at $p < 0.05$
ns – not significant

Plant biomass yield

Soyabean varieties showed a significantly different response with regards to biomass production. TGx 1485-1D produced a lesser dry biomass (4.67t/ha and 2.69t/ha) as against TGx1448-2E which produced a dry biomass of 7.63t/ha and 9.01t/ha in Ipapo and Gbonran fields respectively. This might be due to genotype. However, response to N starter dose was similar across both locations (Tables 3 and 4). The effect of interaction of N starter dose and variety showed that variety TGx 1448-2E produced the highest biomass at N starter dose of 35kgN/ha in Ipapo field and 25kgN/ha in Gbonran field (Figures 3 and 4). These figures revealed the superiority of TGx1448-2E genome over TGx1485-1D in terms of biomass yield.

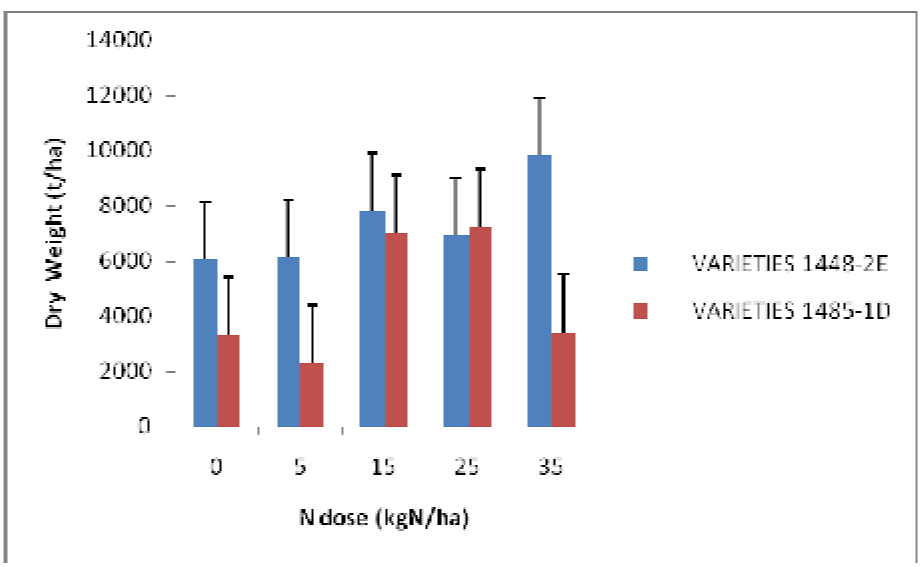

Figure 3: Interactive effect of N dose and variety on dry biomass in Ipapo

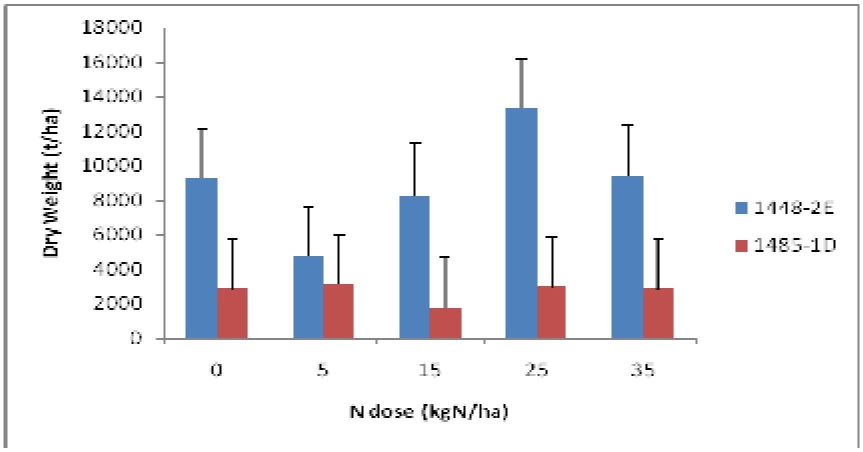

Figure 4: Interactive effect of N dose and variety on dry biomass in Gbonran

Seed dry weight.

There was a significant difference in varietal response to N starter doses in terms of seed dry weight. TGx1448-2E produced a significantly higher seed dry weight than TGx1485-1D.

With respect to N application, 25kg N/ha dose produced the significantly higher seed dry weight than the control (0 kg N/ha); though not significantly different from all other doses in Ipapo field (Table 3). However, there was no significant response in Gbonran field in terms of seed dry weight (Table 4).

Harvest index

There was a significant difference in varietal response in terms of harvest index with variety TGx1485-1D having a significantly higher harvest index than variety TGx1448-2E in both fields (Tables 3 and 4). However, with respect to N application, 5 kgN/ha dose produced the significantly highest harvest index, while the lowest harvest index was produced by zero N application/control in Ipapo field (Table 3). Whereas, in Gbonran filed, there was no difference in response in terms of harvest index (Table 4).

Conclusion

There was varietal difference in response to some traits measured; hence, soyabean performance could be genotype-dependent. The difference between soyabean cultivars in this study showed that soyabean has a broad genetic base with a tremendous variability, which can be utilized by plant breeders for improving soyabean production in this agro-ecology.

Application of N starter dose has less effect on soybean yield and N-uptake in these study-sites representing southern guinea savanna agro-ecology of Nigeria for 2010 cropping season. This might be due to rainfall amount and intensity which may have led to leaching loss of N doses applied (in the form of urea) as rains were heavy and intense at the time of fertilizer application, hence the effects are low.

The use of slow releasing N source such as organic fertilizers is recommended in the region in order to enhance N availability and soil organic matter improvement. This will also reduce leaching and erosion process in the region by improving soil physical and hydrological properties thus enhancing sustainable water and nitrogen utilization.

More still, there is still an open opportunity of adjusting the planting and fertilization application dates to months with less precipitation frequency.

References

Brader, L. (1998). *IITA's benchmark approach to natural resource and management in West and Central Africa*. Paper presented at the International Centers Week, 26-30 October, 1998.Washington DC. USA. 14pp.

Gan Y, I. Stulen, H. Van Keulen and P.J.C. Kuiper (2003). Effect of fertilizer top-dressing at various reproductive stages on growth N2 fixation and yield of three soybean (*Glycine max* L.) genotypes. *Field Crop Res*. 80(2): 147-155.

International Institute of Tropical Agriculture (1984). *Soyabean production training manual*. Manual no 10, IITA, Ibadan, Nigeria. pp 1-390.

Jefing, Y., D. F. Herridge, M.B. Peoples and B. Rerkasean (1992). Effects of N fertilization on N2 fixation and N balance of soybean grain after lowland rice. *Plant and soil* 147: 235-242.

Mehmet O.Z (2008). Nitrogen rate and plant population effects on yield and yield components in soybean. *African Journal of Biotechnology* Vol. 7 (24), pp. 4464-4470, 17 December, 2008

NebGuide web Magazine (2006). *Fertilizer Recommendation for Soyabean*. Institute of Agriculture and Natural Resources, University of Nebraska–Lincoln. 4pp.

Okogun, J.A., N. Sanginga, R. Abaidoo, K.E. Dashiell and J. Diels (2005). On-farm evaluation of biological nitrogen fixation potential and grain yield of Lablab and two soybean varieties in the northern Guinea savanna of Nigeria. *Nutr. Cycl. Agroecosys*. 73: 265-275.

Oluwasemire, K.O.,Alabi, S.O. and Amapu, I.Y. (2002). Nitrogen fertilizer use of maize and ground water pollution under rain-fed conditions in the northen Guinea savanna of Nigeria. In: Umoh, U.J., S.E. Yakubu, H.C.Nzelibe, J. Hallandendu, I.H. Anyawu and E.C. Okolocha (eds.), *1st National Conference on Environmental Degradation: Human Dimensions and Health Implications*. Institute for Development Research, ABU, Zaria, Nigeria. 12th – 15th Nov., 2002. Pp130 -137.

Penas, E.J., and Wiese, R.A. (1987). *Fertilizer suggestions for soybeans*. NebGuide G87-859-A, University of Nebraska, Cooperative Extention, Lincoln, NE. 3pp

Sanginga, N., J.A. Okogun, B. Vanlauwe, J. Diels, F.J. Carsky and K. Dashiell (2001). Nitrogen contribution of promiscuous soybean in maize-based cropping systems. In: *Sustaining soil fertility in West Africa. SSSA* special publication No. 58 pp 157-177.

Steel, R.G.D. and Torrie, J.H. (1987). *Principles and Procedures of Statistics: A Biometrical Approach*. 2nd Edition. McGrawHill Book Company, London, U.K.

Tanimu, B. and J. Y. Yayock (1990). Bambaranut Agronomy. In: *Cropping Scheme Report* 1990. Legumes and oilseeds research programme, Ahmadu Bello University, Institute of Agricultural Research, Zaria, Nigeria.

Taylor, J., Whelan, B., Thylén, L., Gilbertsson, M. and Hassall, J. (2005). Monitoring wheat protein content on-harvester—Australian experiences. p. 369–376. In J Stafford et al. (eds.) *Proc 5th European Conf Prec Agric*, Uppsala, Sweden. 9–12 June. Wageningen Academic Publ., Wageningen.