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Response of Maize Varieties to Some Soil Fertility Management Options in Abakaliki Southeastern Nigeria

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Abstract

Soybean residual manure (SRM) and inorganic fertilizer were evaluated in 2008 and 2009 for growth and yield responses of three elite maize varieties in Abakaliki (latitude 06^0 19´ 407´´ N and longitude 08^0 07´ 831´´ E) in a 4 x 3 factorial arranged in a randomized complete block design in four replications. Soil fertility managements significantly ($p<0.05$) improved yield parameters better than growth, but under SRM + NPK (15:15:15) at 200 Kgha^{-1}, Ikom white (local) had the largest growth and the largest leaf area (9 930.0 cm^2). Fertilizer replacement value of SRM had shelling weight (9.80 gplant^{-1}) more than a half of 18.72g [SRM + NPK (15:15:15)] and 16.79g [NPK (15:15:15)] at 200 Kgha^{-1} only and more than the control (9.50g). Suwan (composite) had heavier shelling weight (14.59g plant^{-1}) than 13.91g (Oba super II, a hybrid) and 12.09g (local). The hybrid had the highest harvest index (60%) but Suwan had the highest 1000 seed weight (209.38g) per plant. SRM with the local for small-scale and SRM + NPK (15:15:15) with Suwan for large-scale production are recommended.

Keywords: Elite maize variety, Soil fertility management, Fertilizer replacement value, Soybean residual manure.

1. Introduction

Maize (U.K.) or Corn (U.S.), *Zea mays* L. is the most important cereal of the *Graminae* family in the world after wheat and rice and is the most important principal staple cereal food, as well as a major component of the traditional mixed cropping system in Southern Nigeria (Onwueme and Sinha, 1991, Daramola, 1993). Before the introduction and expansion of rice production, it has been the principal cultivated cereal and has been used primarily as human food with food energy yield higher than rice and wheat and a source of raw materials for many products (Obi, 1991). It is eaten as whole grain when boiled or roasted and used in its prepared form as pap 'Ogi' or 'Eko' or 'Agidi', while distillers make alcoholic beverages like gin, whisky, beer, etc. out of it. There has been a sharp increase in the local demand for grain maize for use in milling, bread flour, brewing, livestock and other agro-based industries following the ban on its importation by Nigerian government. Cereals and legumes have been identified as agronomic and gastronomic complements. Cereals intercropped or planted after legumes in a rotation utilize the sumptuous nitrogen fixed by legumes to satisfy their nitrogen needs, and methionine and cystine in maize complement the deficient lysine and tryptophan rich in legumes, but deficient in methionine and cystine to give an amino acid with a biological value (BV) of 100 similar to a hen's egg used as a standard in a diet of 1/3 legume and 2/3 cereal (Rhem and Espig, 1991, Kaldy, 1972).

Production levels however still remain very low; less than 2 tonnes/ha on the average and ranks among the lowest in the world (Daynard *et al*., 1969, Rouanet, 1987). Factors such as rapid population growth and urbanization (Spore, 2009, 2010), economic and land tenure problems, soil degradation and fertility loss and cultivation of marginal lands or restricted access to good agricultural land (Kang *et al*., 1984, Kang and Reynolds, 1986, Spore, 1994), land grabbing, decreasing land area per capita and pressure on land (FIAN, 2010), etc. have all contributed to re-emphasizing the need for a more efficient and intensive production of the crop with its consequent implications on the fragile agro-ecological environment of the humid Southeastern Nigeria.

Maize, of all the cereals, makes the highest demands for nutrients, particularly nitrogen (N) deficiency of which limits production more than any other factor (Wilson and Weir, 1970). This is so because N in addition to its numerous functions in plants acts as a regulator that governs to a considerable degree, the utilization of potassium (K), phosphorous (P) and other nutrient elements (Uzo, 1971, Taylor, 1977). The maxim 'no fertilizer no maize is real' which is the reason for the declining production of maize, an indication that maize needs a stable native source of nutrition, which need is more accentuated nowadays the millennium Development Goals (MDGs), particularly those of hunger and environmental sustainability must be met (WOCAT, 2007). Unfortunately, most of the available soil N occurs in the top soil in organic form as humus which is easily eroded or leached away by the high intensity rainstorms of Southern Nigeria (Lal, 1976). The general soil nutrient status of Southeastern Nigeria is categorized below as indices for nutrient requirement developed by the national root crop research institute (NRCRI) soil laboratory, Umudike, Nigeria.

Category	**Total N (%)**	**Available P (Bray-2, mg/kg)**	**Exchangeable K (Cmol/kg)**	**% Organic matter**
Low	<0.15	<15	<0.20	<2.0
Medium	0.15-0.20	15.0-25.0	0.20-0.40	2.0-3.0
Adequate	>0.20	>25.0	>0.40	>3.0

Obviously, there is a growing concern all over the continent of Africa over the decline in the productive capacity of the continent's soil resources due to soil degradation and dwindling soil fertility with cultivation over the past 45 years (Bluffstone and Köhlin, 2011); leading to low per capita food production among smallholder farmers in Africa who remove huge amounts of nutrients from the soil without returning any at the rate of 22 kg N, 2.5 kg P and 15 kg K per hectare over the past 30 years in 37 African countries (Anon, 2003). However, where they apply fertilizers at all, very little fertilizers are used as low as less than 20 kg ha^{-1} which is strikingly low compared with the 200 kg ha^{-1} common in European agriculture (Tittonell *et al.*, 2008). "African Green Revolution" in which fertilizer use is expected to rise from 8 kg ha^{-1} to at least 50 kg ha^{-1} annually by 2015, was launched in Abuja, Nigeria, known as Abuja declaration 2006, since almost all agricultural intensification for food security hinges on heavy use of fertilizers (ENDA, 1977). The 1970 Nobel Peace Prize winner, Norman Borlaug once stated 'If high yielding varieties are the catalyst, fertilizer is the fuel of the green revolution', but the tropical soils do not respond well to some of the temperate farming practices like fertilizers, herbicides and pesticides (Houngnandan *et al.*, 2000).

Decades ago, Knapp (1979) observed that soil as a resource for mankind will be the first one to be totally used up of all the world's resources, with the world's population increasing annually by 2 percent. Currently 1.9 billion hectares of land is affected by significant land degradation (Jiggins, 2008), at the same time the earth is predicted to host more than a billion people in 2050 with a dismal estimate of 5 million births every 10 days as against the 6.8 billion people presently (Spore, 2010). The major challenge is the promotion of a balanced and efficient use of plant nutrients from both organic and inorganic sources at farm and community levels to intensify agriculture in a sustainable manner in an overpopulated world (WOCAT, 2007; IFPRI, 1995).

Despite the importance of inorganic fertilizers, the reduction of subsidy during the economic depression and subsequent complete removal affected the quantity purchased and the cost per bag and consequently the rate of fertilizer consumption fell below the world average. In 1991, the quantity of fertilizer purchased reduced while the official price per bag increased by 116.4% over the price in 1990 (NAFCON, 1990, 1991). An average of 23kg ha^{-1} is consumed in Nigeria (Mustapha, 1992) which is below the 1992 world average of 86kg ha^{-1} and the present United Nations' recommendation of at least 200kg ha^{-1} (Adamu, 1992). In Northern Guinea savannah, 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). NAERLS and APMEU (1996) reported that the land area under maize declined from 2.93 to 2.72 million ha in 1996.

The obverse of this is that no country has ever shaken off poverty (or broken the bounds of low productivity) without ensuring adequate soil fertility (IFA, 2006), which can be achieved through effective and responsible integrated plant nutrition systems (IPNS) approach. Independent scientific studies show that combining inorganic and organic sources of plant nutrients is a beneficial option for the crop and soil system and hence can be of great benefit to both farmers and the environment (IFA, 2003; IFA, 1996). Magen (2007) indicated that the main tools to achieve higher productivity are (1) better soil health and fertility management; (2) water management; (3) integrated plant health management; (4) energy management and (5) post-harvest management. Reports of declining food production due to declining soil fertility and cultivation of marginal zones are reported in literature (ALF, 1989, Dresrusse, 1996, Magen, 2007).

Traditionally, the smallholder farmers in Africa have been able to manage the soil fertility of their farm lands in a sustainable way and the changes in the natural environment were accommodated within the culture and agriculture of their specific geographical areas through skillful land rotation until the rapid changes in population growth during the 20th century (LEISA, 2006). This has made the traditional shifting cultivation acclaimed to be ecologically stable and biologically efficient and suitable for the fragile tropical soils with inherent resilience, 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). Agro-forestry closely approximates the traditional shifting cultivation but suffered low acceptance to great many smallholder farmers (Giller, 2003) which made ICRAF refocus her effort in finding alternative systems more competitive and responsive to the emerging challenges (Catacutan *et al*., 2001). The use of these research technologies and concepts can 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 labour and time expended on them, beyond simply improving soil fertility) among the resource-deprived smallholder farmers, as labour force dwindles and farm sizes shrink (Misiko, 2007). Against this general background, the objectives of the study were to determine the effect of some soil fertility management options and the fertilizer replacement value (FRV) of soybean residual manure (SRM) on the growth and yield of non-legume subsequent maize crop varieties in Abakaliki,

2. Research methods

2.1 Site Description

The experiment was carried out on the research farm of Faculty of Agriculture and Natural Resources Management (FARM), Ebonyi State University, Abakaliki, in Southeastern Nigeria, lying on latitude 06^0 19´ 407´´ N and longitude 08^o 7´ 831´´ E at an altitude of about 447m above sea level with a mean annual rainfall of about 1 700mm to 2 060mm 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).

2.2 Land Preparation

The experimental site suffers consistent bush burning for small rodent hunting during dry seasons by the local youths who access the unfenced area, therefore, light slashing of new flushes of vegetation was made before raised flat beds were constructed in July of 2008 and 2009. Plots were made 0.5m apart while blocks were made 1m apart in an area of $192.5m^2$ (17.5m x 11m).

2.3 Treatment application

The experiment design was a 4 x 3 factorial experiment arranged in a randomized complete block design (RCBD) in four replications. Factor A was four soil fertility management options (soybean residual manure (SRM) alone, SRM + 200 kg ha^{-1} NPK (15:15:15), NPK (15:15:15) at 200 kg ha^{-1} alone and a control), while factor B was three maize varieties (Oba super II (a hybrid), Suwan (a composite) and Ikom white (a local or a farmer's variety), with 12 treatment combinations giving a total of 48 plots in the experiment.

2.3 Seed sowing

Flat seedbeds were made on a plot from which soybean was harvested the previous year and maize seeds were sown immediately at a plant spacing of 75cm x 25cm on 48 plots of 2m x 1m. The viability index was 100% hence, justifying one seed/hole and 12 maize stands per plot being established. Oba Super II and Suwan seeds were bought from a major distributor of Premier Seeds based in Enugu state, Nigeria (Molon Agro Services) while Ikom White was obtained from a local market in Ebonyi State.

2.4 Field maintenance

The inorganic fertilizer [NPK (15:15:15)] was applied three weeks after planting to the designated plots. Three weeding periods were manually done before harvest in each of the experiments when the need arose to maintain weed-free plots throughout the growing periods with small-blade Indian dwarf hoe. During hoeing, soil heaps were provided around the plant stands to prevent lodging.

2.5 measurements

The average soil properties of the research farm from soil samples collected and analyzed before planting and after harvesting in 2008 and 2009 planting years are presented in Table 1. Measurements were made on four innermost plant stands within the innermost rows of the plots on the following growth and yield parameters such as, percentage germination at five days after planting (DAP), number of leaves, leaf area, leaf area index and plant height at tasselling stage, un-de-husked cob weight per plant, 1000 seed weight, shelling weight per plant and de-husked cob weight per plant at harvest. All data collected were subjected to analysis of variance (ANOVA) using the GenStat statistical model, version 2 (Release 7.22 DE 3) arranged according to Steel and

Torrie (1980), in separate years and years combined. Treatment means were separated using Fisher's least significant difference (F-LSD = LSD) as described by Obi (1986) to identify significant treatment effects in the experiments.

3. Results and Discussion

3.1 Soil test report

In Table 1, the soil physical and chemical properties of the experimental site showed that the pH values before planting was (5.50) in both years, but improved a little after harvesting (5.55) in 2008 and was higher (5.85) in 2009. This reduction in acidity is strange because soybean and maize planting is not known to decrease acidity. Soils of low pH values are often low in plant nutrients such as calcium (Ca), Potassium (K), phosphorus (P) and some micronutrients may also be limiting, due to plant nutrient immobilization earlier observed by Sarrantonio (1991), Duong and Diep (1986). The importance of soil test is therefore predicated on optimizing input use, sustainable agricultural productivity and improvement of rural livelihood as soil productivity is declining in the face of rapid population growth (Spore, 2010) as reported by Munson and Runge (1990) and Place *et al*. (2003). However, the high available phosphorus (P) present in the area before planting (20.00 mg Kg^{-1} in 2008 and 19.00 mg Kg^{-1} in 2009) and after harvesting (22.11 mg Kg^{-1} in 2008 and 24.57 mg Kg^{-1} in 2009) could be the reason the soil fertility has been supporting heavy agricultural activity despite the acidic nature of the area, in accordance with the report of Elliot *et al.* (2009), that P tends to move down hill across the field and is less likely to leach vertically into the ground water.

3.2 Growth and yield parameters of maize influenced by soil fertility management options

Table 2 displays a significant ($p<0.05$) improvement on all the growth parameters [number of leaves, plant height (cm), leaf area (cm^2) and leaf area index (LAI)] per plant, across the years except in 2009 and yield parameters (undehusked cob weight (g), dehusked cob weight (g), shelling weight (g), 1000 seed weight (g) and harvest index) per plant across the years by the soil fertility management options. SRM + NPK (15:15:15) consistently had the highest growth and yield parameters over other soil fertility management options as it exhibits the combined nutrient advantage of soybean residual manure and the inorganic fertilizer qualities, which corroborates other independent scientific studies that combining inorganic and organic sources of plant nutrients is a beneficial option for the crop and soil system and hence can be of great benefit to both farmers and the environment (IFA, 2003; IFA, 1996). However, narrow differences which were observed across the years in the growth parameters demonstrated the potential of SRM in approximating the traditional shifting cultivation (Anon, 2003, Glen and Tipper, 2001) to replace elaborate fertilizing regime common with maize production in the Northern Guinea savannah (Manyong *et al*., 2001). In the combined analysis of 2008 and 2009 yield parameters, SRM + NPK (15:15:15) had the highest undehusked cob weight of 29.42 g, dehusked cob weight 23.59 g, shelling weight 18.72 g, 1000 seed weight 196.73 g, and harvest index 0.59, followed by NPK (15:15:15) with 28.12 g, 20.50 g, 16.79 g, 190.05 g and 0.57; then SRM with 19.12 g, 13.38 g, 9.80 g, 190.71 g and 0.56, while the control had 17.29 g, 13.21 g, 9.50 g, 187.18 g and 0.52, respectively. This vividly agrees with the observations of Wilson and Weir (1970), Uzo (1971) and Taylor (1977) that maize requires high nitrogen (N), deficiency of which limits production more than any other factor as it considerably governs the utilization of other elements.

3.3 Growth and yield parameters of maize influenced by maize varieties

In Table 3, Oba super II, Suwan and Ikom white significantly ($p<0.05$) made differences in their yield performances in 2008, 2009 and the years combined with Oba super II having the highest HI of 0.61 in 2008, 2009, and 0.60 in the years combined, followed by Suwan with 0.58 and the local with 0.50 in the years combined. However, Suwan had the highest 1000 seed weight (194.30, 199.54 and 209.38 g) per plant consistently across the years. 1000 seed weight correlates highly with food energy production which maize has over other cereals as stated by Obi (1991). Oba Super II had the highest shelling weight (17.33 g) in 2008 and (17.31g) in 2009, but Suwan had the highest (14.59g) per plant in the years combined. The differences observed in the growth parameters were not purely as a result of the treatment effect, because Ikom white naturally appeared to be a large plant than others and stood out as a giant plant with its many long leaves. The local had the highest number of leaves (15.34), followed by Suwan (14.25), the largest leaf area (9 550.0cm^2), followed by Suwan (8 527.0cm^2) and was the tallest plant (199.75cm), followed by Suwan (167.47cm) in the years combined and also across the years.

Variety x soil fertility management options interaction significantly ($p<0.05$) influenced large leaf area production as presented in Table 4. The variety x soil fertility treatments improved the leaf area with the highest (10 328.0 cm^2) recorded in 2008, 9 932.0 cm^2 in 2009 and 9 930.0 cm^2 in the years combined by the Local under SRM + NPK (15:15:15). The Local (Ikom white) consistently had the largest leaf area also across the soil fertility management options across the years. The Local, with this large volume of leaf area can sustain sizeable ruminants within the cropping system by the smallholder farmers in this zone which incidentally will enhance the soil fertility sustainably.

4. Conclusion

The resource constrained smallholder farmers, through a judicious use of legume crops especially pulses like soybean, can improve soil fertility, intensify crop production and halt soil degradation effectively, in this agro-ecological zone, as it has been established that agro-forestry closely approximates the traditional shifting cultivation with its resilient benefits. It also has high acceptance by smallholder farmers because it has direct commensurate compensation as food, fertilizer, fire wood and fodder to the farmers to feed our teeming population. Additionally, the abundant sustainable quality cheap plant protein and grain production system will guarantee food security and rural transformation in Africa by using the soybean-based soil fertility management option to increase the production of both maize and soybean grains to tame hunger pangs in this zone. Fertilizer replacement value of SRM produced a shelling weight (9.80 $gplant^{-1}$) more than a half of 18.72g from SRM + NPK (15:15:15) and 16.79g from NPK (15:15:15) only and more than the control with 9.50g. Suwan had heavier shelling weight (14.59g $plant^{-1}$) than 13.91g from Oba super II and 12.09g from the local. The hybrid had the highest harvest index (60%) but Suwan had the highest 1000 seed weight (209.38g) per plant. SRM with the local can sustain a small-scale maize production while SRM + NPK (15:15:15) with Suwan or the hybrid can sustain large-scale production, hence, highly recommended as a welcome technology for the fragile tropical soils of this zone. This zone is predicted to support a large population growth in the face of the present raging global climate change.

Table1: Some soil physical and chemical properties of the experimental area before planting and after harvesting

	2008		2009	
Chemical analysis	Before	After	Before	After
pH (H_2O)	5.50	5.55	5.50	5.85
% Total N	0.14	0.18	0.15	0.20
Available P $mgKg^{-1}$	20.00	22.11	19.00	24.57
% Organic carbon	1.64	1.01	1.29	1.12
% Organic matter	2.83	1.74	2.22	1.93
Exchangeable cations ($cmol\text{-}kg^{-1}$)				
Calcium (Ca)	3.00	2.75	2.60	2.36
Magnesium (Mg)	1.60	1.65	1.70	1.72
Potassium (K)	0.13	0.15	0.16	0.18
Sodium (Na)	0.21	0.20	0.20	0.20
Soil particle analysis (%)				
Sand	64.50	63.50	65.00	64.60
Clay	25.00	25.00	26.00	25.50
Silt	11.00	11.02	11.01	11.04
Texture	Sandy loam	sandy loam	sandy loam	sandy loam

Table 2: Main effect of soil fertility management options on the growth and yield of maize varieties

Treatment	No. of leaves	Plt Ht cm	Leaf area (cm^2)	Leaf area index	Ud cob wt($gplt^{-1}$)	Dh.cob wt($gplt^{-1}$)	Sh.wt ($gplt^{-1}$)	1000 sdwt(g)	HI
2008									
Control	13.92	175.00	8 514.0	4.54	19.69	14.58	7.67	187.83	0.54
NPK	14.50	175.25	9 050.0	4.79	31.58	23.58	17.33	192.85	0.57
SRM	14.17	175.67	8 782.0	4.68	21.25	12.83	9.83	194.30	0.56
SRM+NPK	14.83	185.25	9 141.0	4.83	32.50	25.42	19.58	206.41	0.61
LSD (P=0.05)	0.41	4.45	351.2	0.24	2.47	2.32	2.20	3.39	0.5
2009									
Control	14.17	169.92	8 620.0	4.60	17.33	12.17	9.33	186.52	0.51
NPK	14.33	170.58	8 789.0	4.69	24.67	19.42	16.25	187.24	0.57
SRM	14.17	170.00	8 664.0	4.62	18.58	13.58	10.33	187.12	0.56
SRM+NPK	14.42	172.42	8 815.0	4.70	26.33	22.33	17.92	187.06	0.58
LSD (P=0.05)	0.39	5.13	371.4	0.20	3.14	3.11	3.03	0.90	0.5
2008 and 2009 Combined									
Control	14.00	172.12	8 700.0	4.62	17.29	13.21	9.50	187.18	0.52
NPK	14.46	173.50	8 786.0	4.71	28.12	20.50	16.79	190.05	0.57
SRM	14.17	172.58	8 723.0	4.65	19.12	13.38	9.80	190.71	0.56
SRM+NPK	14.58	178.83	8 960.0	4.74	29.42	23.59	18.72	196.73	0.59
LSD (P=0.05)	0.27	3.39	252.0	0.14	2.01	1.97	1.89	1.59	0.03

Key: LSD = F-LSD = Fisher's least significant difference, SRM = Soybean residual manure, NPK = NPK (15:15:15), Ud cob = undehusked cob, Dh.cob = dehusked cob, Sh.wt = shelling weight, ($gplt^{-1}$) = gramme per plant, sdwt = seed weight, Plt Ht = plant height.

Table 3: Main effect of soil fertility management options on the growth and yield of maize varieties

Variety	No. of leaves	plt Ht cm	leaf area (cm^2)	leaf area index	Ud cob wt($gplt^{-1}$)	Dh.cob wt($gplt^{-1}$)	Sh.wt ($gplt^{-2}$)	1000 sdwt(g)	HI
2008									
Local	15.31	207.44	9 141.0	4.54	21.25	14.58	9.67	187.83	0.57
Oba	13.44	155.44	8 514.0	4.83	31.58	23.58	17.33	192.85	0.61
Suwan	14.31	170.50	9 050.0	4.79	19.67	12.83	7.83	194.30	0.54
LSD (P=0.05)	0.36	3.85	351.2	0.24	2.47	2.32	2.20	3.39	0.5
2009									
Local	15.38	192.06	9 487.0	5.06	17.06	13.06	9.69	171.66	0.49
Oba	13.19	155.69	8 182.0	4.36	25.06	19.94	17.31	189.76	0.61
Suwan	14.19	164.44	8 497.0	4.53	23.06	17.88	14.38	199.54	0.57
LSD (P=0.05)	0.34	4.44	321.7	0.17	2.72	2.69	2.63	0.78	0.04
2008 and 2009 Combined									
Local	15.34	199.75	9 550.0	5.09	22.41	16.28	12.09	171.10	0.50
Oba	13.31	155.69	8 300.0	4.40	24.09	18.28	13.91	193.02	0.60
Suwan	14.25	167.47	8 527.0	4.55	25.47	19.03	14.59	209.38	0.58
LSD (P=0.05)	0.29	3.95	262.7	0.18	1.69	1.54	1.55	2.13	0.04

Key: Oba = Oba super II, LSD = F-LSD = Fisher's least significant difference, Ud cob = undehusked cob, Dh.cob = dehusked cob, Sh.wt = shelling weight, ($gplt^{-1}$) = gramme per plant, sdwt = seed weight, Plt Ht = plant height.

Table 4: Variety x soil fertility management options interaction on leaf area (cm^2) of maize varieties

Variety	Control	NPK(15:15:15)	SRM	SRM+NPK	Mean
2008					
Local	8 942.0	9 819.0	9 370.0	10 328.0	9 614.0
Oba super II	8 194.0	8 531.0	8 379.0	8 595.0	8 425.0
Suwan	8 068.0	8 597.0	8 500.0	9 139.0	8 576.0
Mean	8 401.3	8 982.3	8 749.7	9 354.0	
2009					
Local	8 949.0	9 533.0	9 532.0	9 932.0	9 487.0
Oba super II	7 695.0	8 444.0	8 114.0	8 477.0	8 182.0
Suwan	8 232.0	8 392.0	8 344.0	9 020.0	8 497.0
Mean	8 292.0	8 789.7	8 663.3	9 143.0	
2008 and 2009 Combined					
Local	8 946.0	9 876.0	9 451.0	9 930.0	9 550.0
Oba super II	7 944.0	8 504.0	8 246.0	8 504.0	8 300.0
Suwan	8 446.0	8 539.0	8 470.0	8 651.0	8 527.0
Mean	8 445.3	8 973.0	8 722.3	9 028.3	

2008: F-LSD (P=0.05) =304.2 for comparing two varietal means
=351.2 for comparing two treatment means
=608.4 for comparing variety x treatment interaction means

2009: F-LSD (P=0.05) =321.7 for comparing two varietal means
=371.4 for comparing two treatment means
=643.3 for comparing variety x treatment interaction means

2008 and 2009 Combined: F-LSD (P=0.05) =262.7 for comparing two varietal means
=252.0 for comparing two treatment means
=447.2 for comparing variety x treatment interaction means

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