Performance of 12 sweet orange cultivars in the south-western Nigeria

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Abstract — Introduction. Citrus fruit produced presently in Nigeria come from five assorted cultivars of the Nigerian green orange. The trees, which are from unselected seedling trees, produce irregular yield and low fruit quality. Seven new cultivars were introduced from the United States in order to broaden the genetic base of the Nigerian orange trees. In this study, performance of these 12 cultivars was assessed in the environmental conditions of Nigeria. **Materials and methods**. Budded seedlings were planted out at 7 m × 7 m in randomised complete block design with three-tree plots replicated four times. Grove maintenance was similar to that carried out in commercial groves. Growth measurements, trunk cross-sectional area at 5 cm above bud-union point and canopy volume, were recorded. Adult tree fruit production was studied during 5 consecutive years, at the rate of two harvests a year: in April-May and November-December. The cultivars were evaluated using IPGRI standards. **Results and discussion**. All the cultivars tested, except Carter Navel, exhibited favourable adaptability to the growing conditions in Nigeria. Two Nigerian cultivars, Etinan and Umudike, out-yielded all other cultivars. Agege 1, Bende and Lue-gin-gon, local cultivars, and the introduced Pineapple recorded highest fruit numbers per canopy m^3. There was no significant difference in fruit quality amongst the cultivars. **Conclusion**. Finally, three Nigerian cultivars, Agege 1, Etinan and Umudike, and two foreign cultivars, Pineapple and Washington Navel, are promising for citrus production in the ecological zone of south Nigeria. (© Elsevier, Paris)

Nigeria / *Citrus* / variety trials / agronomic characters

Performance de 12 cultivars d'orange douce dans le sud-ouest nigérian.

Résumé — Introduction. Les agrumes produits actuellement au Nigeria proviennent de cinq cultivars de l'orange verte locale. Les arbres, issus de semis non sélectionnés, ont des rendements irréguliers et des fruits de médiocre qualité. Sept nouveaux cultivars ont été introduits des États-Unis pour élargir la base génétique des orangers cultivés au Nigeria. La production de ces 12 cultivars a été évaluée dans les conditions climatiques du Nigeria. **Matériel et méthodes**. Les arbres ont été mis en place au stade de plantules greffées, à une densité de 7 × 7 m, selon un dispositif expérimental en randomisation totale, constitué de quatre blocs de douze parcelles élémentaires de trois arbres. Le suivi cultural a été calqué sur celui utilisé en vergers commerciaux. Des indicateurs de la croissance de l'arbre – surface de la section du tronc à 5 cm au-dessus du point de greffe et volume de la canopie – ont été enregistrés. La production d'arbres adultes a été étudiée pendant 5 années consécutives, à raison de deux récoltes par an, en avril–mai et novembre–décembre. Les cultivars ont été évalués à partir des standards définis par l'IPGRI. **Résultats et discussion**. Tous les cultivars testés, sauf Carter Navel, se sont bien adaptés aux conditions de croissance du Nigeria. Deux cultivars nigérians – Etinan et Umudike – ont eu des rendements nettement supérieurs aux autres. Agege 1, Bende et Lue-gin-gon, des cultivars locaux, et Pineapple, une introduction, ont donné de nombreux fruits par mètre cube de canopie. La qualité des oranges n'a pas varié significativement d'un cultivar à l'autre. **Conclusion**. Finallement, trois cultivars nigérians – Agege 1, Etinan et Umudike – et deux cultivars étrangers – Pineapple et Washington Navel – seraient prometteurs d'une production d'agrumes dans la zone écologique du sud nigérian. (© Elsevier, Paris)

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1. introduction

Citrus cultivation which started in the south west zone of Nigeria in the early 1920s is now a nation- wide affair [1, 2]. As production increases, citrus fruit is gaining importance in the daily diet of Nigerians [2, 3]. More than 90% of citrus fruits produced presently in Nigeria is from assorted varieties of sweet orange [1]. Most of these come from the Nigerian green orange (NGO) type which includes the cultivars Agege 1, Bende, Etinan, Meran and Umudike. More than 90% of existing trees are from mainly unselected seedling trees either grown in mixed cropping system with cocao or kola or established in yard or garden and in few places as isolated citrus orchards [3–5]. As a result of this planting habit and the non-selected nature of the bearing trees, fruit yields are low, irregular and of low quality. However, more recent plantings were made from grafted trees in properly set out citrus orchards. Because of the dearth of information on the yield performance and fruit quality attributes of cultivars collected from within and outside Nigeria, it was essential to evaluate and characterise these cultivars in the different ecological zones of the country and to select adaptable and precocious bearers of top quality fruits that will readily be acceptable to citrus growers nation wide. This was the major objective of the present study.

2. materials and methods

The sweet orange cultivars studied included seven introductions from Florida, USA: Carter Navel, Hamlin, Luegin-gon, Parson Brown, Pineapple, Valencia Late, Washington Navel, and five local Nigerian cultivars: Agege 1, Bende, Etinan, Meran and Umudike. Scions of these cultivars were budded on Cleopatra mandarin (*Citrus reshni*) rootstock seedlings. Before transplanting to the field, in May–June 1977, at a spacing of 7m × 7m, the budded seedlings were grown in a nursery up to transplantable age-size.

Experimental design was a randomised complete block with three-tree plot, replicated four times. Twelve trees per cultivar were studied. The rootstocks and scion trees were indexed and were free of viruses.

The experimental site was a tropical rain forest having a bimodal rainfall with a mean annual precipitation of 1250 mm and monthly temperature of 26.8 °C (*table I*). The soil of the trial site was sandy clay loam.

2.1. field maintenance practices

Grove maintenance was similar to that in commercial groves. This included tractor slashing of the interrow spaces and/or weed-killer application three times a year. In the second year of establishment, trees received a first application of fertilizer in May–June, then twice annually, the dose increasing gradually to 3 kg·tree^{-1} at fruiting stage. Trees were irrigated with overhead sprinklers up to the early stage of fruiting. Routine spraying against insect pests was carried out using Cymbush 10EC or Sharpaplus. Pruning of parasitic mistletoe and epyphitic orchids was done as the need arose. Growth measurements which included tree height, girth at 5 cm above and below bud union and canopy spread were carried out and canopy volume was calculated using the formula V = 0.524 × height × width × 2 [6].

Fruit were harvested twice annually in April–May and November–December for minor and major crop seasons, respectively. Fruit number and weight in kg·tree^{-1} were recorded on each harvest. Varieties were evaluated according to the IPGRI criteria and standards (*table II*).

2.2. sampling

The quantitative and qualitative measurements for each citrus cultivar were based on ten fruits per tree, or 30 fruits

Table I.
Mean monthly rainfall and temperature during the years (1994–1996), at the study site in Nigeria.

Months	1994		1995	1996	
	Rainfall (mm)	Temperature (°C)	Rainfall (mm)	Rainfall (mm)	Temperature (°C)
January	0	26.0	0	0	26.8
February	0	28.1	0	54.2	28.0
March	31.4	30.0	79.4	128.4	28.1
April	63.3	29.0	154.8	126.6	29.8
May	228.5	28.0	358.4	115.0	27.4
June	92.0	26.4	168.7	169.1	26.4
July	167.4	24.4	150.6	214.9	25.0
August	74.7	25.0	266.1	228.4	24.3
September	134.7	26.0	137.7	204.4	24.3
October	220.4	26.0	143.0	131.5	25.6
November	22.6	27.0	25.6	0	27.1
December	0	26.0	0.5	0	29.4

Table II.
Traits measured on the sweet orange varieties studied in the tropical rain forest conditions of Nigeria.

Trait measured	Method of measurements
Flowering date	Corresponding to citrus E phenological stage (open flower)
Flowering-maturity period	From the E stage to maturity as determined by the dry extract/acid ratio
Tree cross sectional area	Tree cross sectional area at 5 cm above bud union point (cm^2)
Tree canopy volume	Tree canopy calculated from width and height (m^3)
Yield per tree	Mean yield from three trees
Fruit weight	Mean (g)
Fruit equatorial diameter	Fruit diameter (cm)
Fruit equatorial circumference	Fruit circumference (cm)
Fruit peel thickness	Measured from epicarp to mesocarp (mm)
Juice content	Percentage of the juice weight relative to the fruit weight
Juice soluble sugars	Dry extract measured by refractometry (° brix)
Juice acidity (A)	Citric acid content (g·100 mL of juice) assessed by neutralization with a sodium base

Table III.
Varietal adaptibility of 12 sweet orange cultivars tested in the tropical rain forest conditions of Nigeria: number of trees remaining in 1998 from the 12 trees transplanted in 1977.

Cultivar	Origin	Number of trees remaining
Agege 1	Local cultivar	12
Bende	Local cultivar	12
Carter Navel	Introduction from United States	4
Etinan	Local cultivar	9
Hamlin	Introduction from United States	10
Lue-gin-gon	Introduction from United States	12
Meran	Local cultivar	9
Parson Brown	Introduction from United States	11
Pineapple	Introduction from United States	11
Umudike	Local cultivar	12
Valentia late	Introduction from United States	12
Washington Navel	Introduction from United States	9

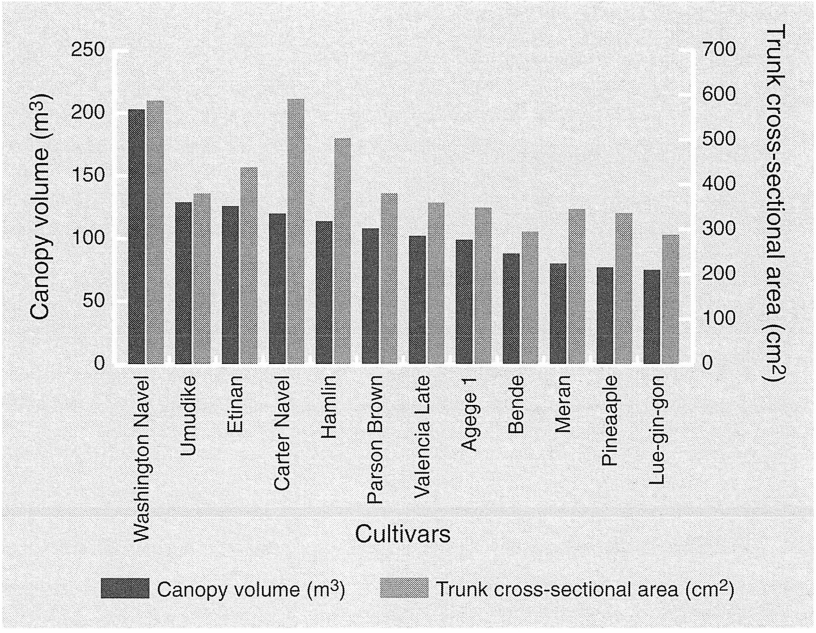

Figure 1.
Mean trunk cross-sectional area at 5 cm above bud union point and mean canopy volume of 12 cultivars tested in the tropical rain forest conditions of Nigeria.

per three-tree plot, harvested twice annually from 1990 to 1994.

All cultivar data collected were statistically analysed using analysis of variance. Cultivar rating was done using performance index values according to Fasoulas line method [7].

3. results and discussion

3.1. varietal adaptability

Except for the Carter Navel of which only four trees of the 12 trees initially transplanted survived to date, all foreign introductions and local cultivars exhibited favourable adaptability to the growing conditions of Nigeria: Etinan, Meran and Washington Navel have nine surviving trees each; Hamlin has ten trees; Parson Brown and Pineapple have 11 trees each; and Agege 1, Bende, Lue-gin-gon, Valencia Late and Umudike have 12 surviving trees each (*table III*).

3.2. vegetative characteristics

For the character of trunk cross sectional area, Carter Navel, Hamlin and Washington Navel are superior to the nine other cultivars tested. However, Washington Navel exhibits superiority over all other cultivars in canopy volume. For these two characteristics, Pineapple and Lue-gin-gon are inferior to other cultivars of the test (*figure 1*).

3.3. ripening period

All 12 sweet orange cultivars, without exception, flowered twice a year: a March flower production for the September–November major crop, and a September flower production for the March–April minor crop. According to length of the ripening period, three groups were identified for each of the minor and major crop seasons (*table IV*): the early season, the full-mid season

Table IV.
Ripening periods for different sweet orange varieties tested in the environmental conditions of Nigeria; citrus produce fruits twice annually.

March–June minor crop			August–December major crop		
Early season March	Full season/mid-season April–May	Late season June–July	Early season August	Full season Sept.–Nov.	Late season Dec.–Feb.
Parson Brown	Pineapple	Lue-gin-gon	Parson Brown	Pineapple	Lue-gin-gon
Washington Navel	Hamlin	Valencia Late	Washington Navel	Hamlin	Valencia
Agege 1	Bende		Agege 1	Meran	
Etinan	Meran		Etinan	Bende	
Umudike	Carter Navel		Umudike	Carter Navel	

and the late season groups of which the cultivar ripening periods last 5.5 months, 6.5 months and 7 months after flowering, respectively.

3.4. production

Mean fruit weight in Washington and Carter Navels were superior to all other cultivars (*figure 2*). In fact, Navel varieties had a very high mean fruit weight, reaching 268 g and 252 g for Carter and Washington respectively, as compared to only 175 g for Hamlin and 158 g for Parson Brown. Mademba-Sy et al. [8] reported similar superiority of fruit weight in Washington in relation to blond and blood oranges.

Mean cumulated yields for all cultivars were 104 kg, 260 kg, 317 kg, 474 kg and 530 kg at 8 years, 9 years, 10 years, 11 years and 12 years, respectively. The mean cumulated yield of 104 kg at 8 years corroborates some results obtained by Mademba-Sy et al. [8] in New-Caledonia.

Two cultivars, Etinan and Umudike, with cumulated yields per tree of 725 kg and 772 kg, respectively, stand out as precocious fruit bearers (*figure 3*). Navels were lowest in yield with 378 kg and 321 kg for Washington and Carter, respectively. Because Navels are superior to all other cultivars in canopy volume and fruit weight (*figures 1, 2*),

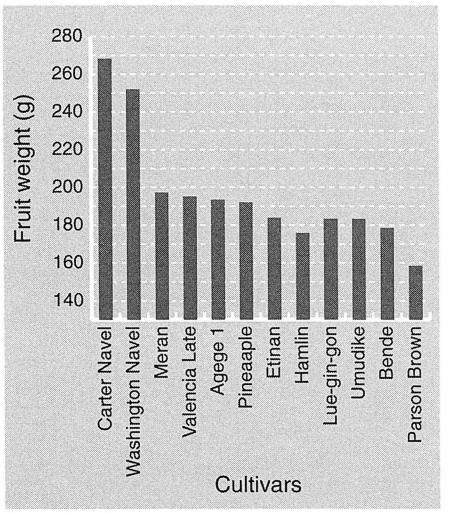

Figure 2.
Mean fruit weight of 12 cultivars tested in the tropical rain forest conditions of Nigeria over five years (1985–1989).

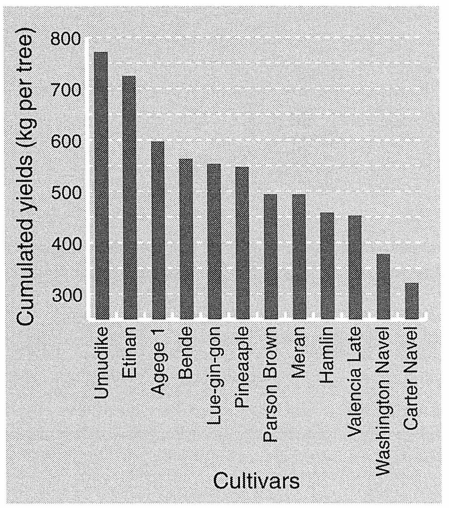

Figure 3.
Mean cumulated yield per tree of 12 cultivars tested in the tropical rain forest conditions of Nigeria over five years (1985–1989).

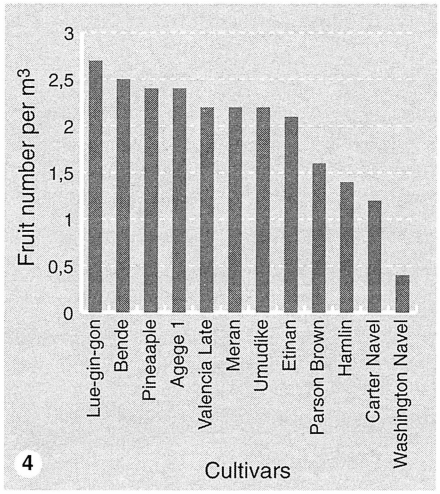

Figure 4.
Mean yield efficiency of 12 cultivars tested in the tropical rain forest conditions of Nigeria over five years (1985–1989), assessed with fruit number per m^3.

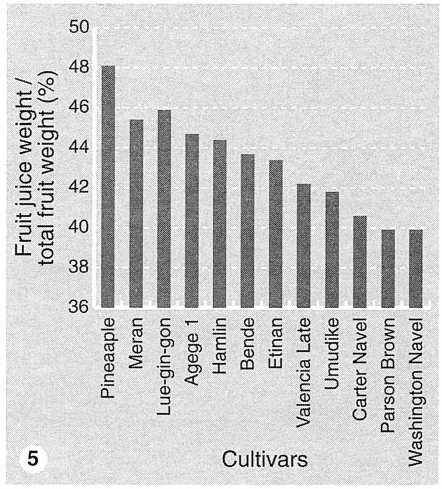

Figure 5.
Mean fruit juice content of 12 cultivars tested in the tropical rain forest conditions of Nigeria, assessed with the fruit juice weight/fruit weight ratio.

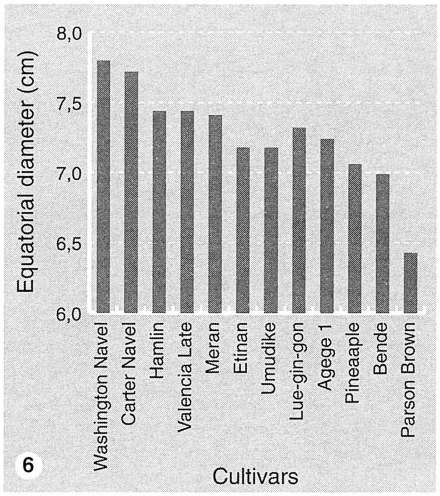

Figure 6.
Mean fruit equatorial diameter for 12 cultivars tested in the tropical rain forest conditions of Nigeria.

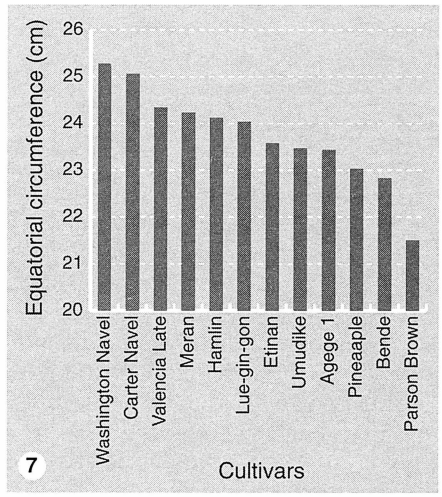

Figure 7.
Mean fruit equatorial circumference for 12 cultivars tested in the tropical rain forest conditions of Nigeria.

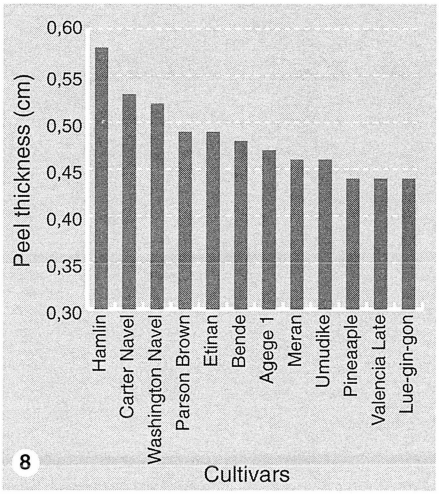

Figure 8.
Mean fruit peel thickness of 12 cultivars tested in the tropical rain forest conditions of Nigeria.

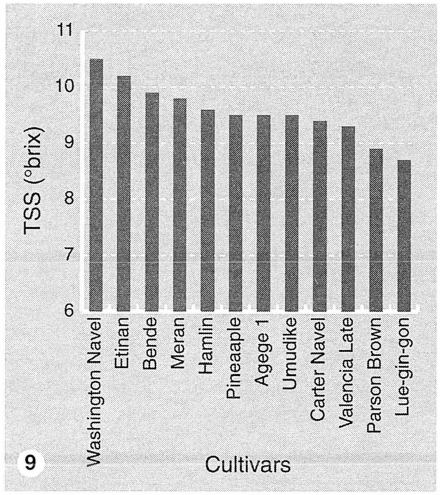

Figure 9.
Mean juice total soluble sugars of 12 cultivars tested in the tropical rain forest conditions of Nigeria, assessed with soluble dry extracts measured by refractometry.

these low cumulated yields can be explained by their low yield efficiency assessed by the fruit number per canopy m^3 (*figure 4*). Lue-gin-gon, Bende, Pineapple and Agege 1, which were the best for this last character and produced high cumulated yields, have compact canopies.

3.5. fruit quality

There was no appreciable significant difference in juice content among cultivars, however, Pineapple was juicest (*figure 5*). The large fruit weight and size, equatorial diameter and equatorial circumference, exhibited by navels were not matched with corresponding high juice content (*figures 5, 6, 7*). On the other hand, Parson Brown, which produced smallest sized fruit, had, with Washington Navel, the lowest juice content. Navels and Parson Brown were observed to be prone to granulation. This phenomenon is most serious in major or dry season crops.

Hamlin was significantly superior to all other cultivars in peel thickness (*figure 8*).

The cultivars differed in terms of soluble dry extract (SDE) and acidity: Washington Navel, Etinan, Bende and Meran, with the highest soluble dry extracts, 10.5, 10.2, 9.9 and 9.8, respectively, were significantly superior to the eight other cultivars (*figure 9*). Lue-gin-gon recorded the least soluble dry extract (SDE = 8.7). Pineapple and Carter Navel were more acid (A = 1.10 g) than the other cultivars (*figure 10*) tested.

As far as vitamins were concerned, Bende, a local cultivar, and Hamlin, were richest in vitamin A: 132 mg·100 mL^{-1} and 114 mg·100 mL^{-1}, respectively (*figure 11*). On the other hand, there were no significant differences among cultivars in vitamin C content which varied from 53.9 to 63.9 mg·100 mL^{-1}.

Generally speaking, the oranges had a yellow fruit internal colour while, in the early and full/mid season cultivars, the orange fruit's external colour was virtually non-existent, and, even in the late season cultivars, the orange fruit's external colour was less intense than the one of fruits from the Mediterranean and subtropical zones. The non-realization of a full anthocianin pigment appearance in tropical orange fruits is the result of a lack of low temperatures. The minimum temperature, under which the present study was carried out, was 24.4 °C; this explains the absence of a full orange colour in Nigerian oranges.

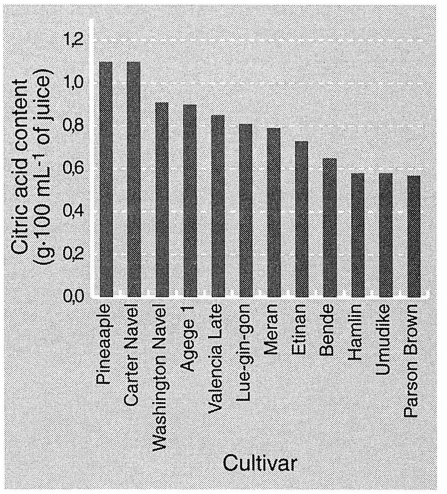

Figure 10.
Mean juice total acidity of 12 cultivars tested in the tropical rain forest conditions of Nigeria.

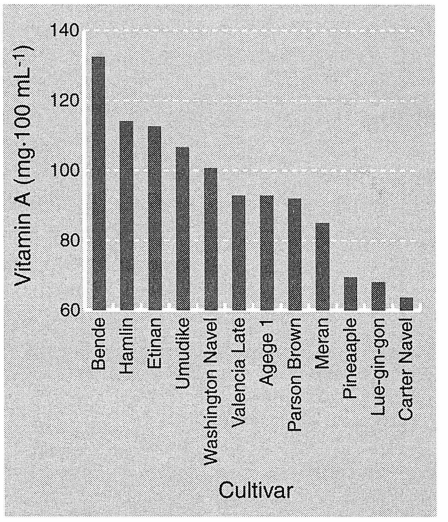

Figure 11.
Mean juice vitamine A content of 12 cultivars tested in the tropical rain forest conditions of Nigeria over 5 years (1985–1989).

4. conclusion

On the basis of this study, Agege 1, Etinan, Hamlin, Parson Brown, Pineapple, Umudike, Valencia Late and Washington Navel stand out as promising for citrus production in the south west ecological zone of Nigeria. Although Washington Navel is inferior to other cultivars in yield and juice content, it has to be included in the list, because it is the sweetest of all the cultivars and it is popular amongst citrus growers.

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Rendimiento de 12 cultivares de naranja dulce en el sudoeste de Nigeria.

Resumen — Introducción. Los cítricos que se producen actualmente en Nigeria provienen de cinco cultivares de la naranja verde local. Los árboles, procedentes de semillas no seleccionadas, tienen rendimientos irregulares y dan frutos de una calidad mediocre. Se han introducido siete nuevos cultivares de los Estados Unidos para ampliar la base genética de los naranjos cultivados en Nigeria. **Material y métodos**. Los árboles se colocaron en la fase de plántulas injertadas, con un distanciamiento de 7 m × 7 m, según un dispositivo experimental de aleatoriación total constituido por cuatro bloques de doce parcelas elementales de tres árboles. Se ha realizado un seguimiento del cultivo semejante al que se practica en las plantaciones comerciales. Se anotaron los indicadores del crecimiento del árbol: superficie de la sección del tronco 5 cm por encima del punto de injerto y volumen de la cubierta de copas. Se estudió la producción de los árboles adultos durante cinco años seguidos y a razón de dos cosechas anuales, en abril-mayo y en noviembre-diciembre. Los cultivares se evaluaron a partir de los modelos definidos por el IPGRI. **Resultados y discusión**. Todos los cultivares sometidos a prueba, excepto Carter Navel, se adaptaron bien a las condiciones de crecimiento de Nigeria. Dos cultivares autóctonos -Etinan y Umudike- tuvieron rendimientos claramente superiores a los otros. Agege 1, Bende y Lue-gin-gon – cultivares locales – y Pineapple – cultivar introducid – dieron abundantes frutos por m^3 de cubierta de copas. La calidad de las naranjas no presentó variaciones importantes entre los diferentes cultivares. **Conclusión**. Al final, tres cultivares autóctonos – Agege 1, Etinan y Umudike– y dos extranjeros – Pineapple y Washington Navel – pueden ser los más prometedores para una producción de cítricos en la zona ecológica del sur de Nigeria. (© Elsevier, Paris)

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