

Original Research Article

The study of morphological characteristics, dry matter production and yield of Differential response of four sugarcane (*Saccharum officinarum* L.) varieties to NPK 20:10:10 fertilizer in South-Western Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author KAN designed the study, wrote the protocol and wrote the first draft of the manuscript. Author OOO and KAN reviewed the experimental design and all drafts of the manuscript. Authors KAN and VOC managed the analyses of the study. Authors KAN and VOC performed the statistical analysis. All authors read and approved the final manuscript

ABSTRACT

The study was carried out during the wet cropping season of 2000 and dry season of 2001, respectively at the farm site of Olabisi Onabanjo University, Ago-iwoye, Ogun State in South-West zone of Nigeria to determine and compare the weight of cane, dry matter and yield of four varieties of sugarcane (*Saccharum officinarum* L.) in response to NPK 20: 10: 10 fertilizer. Varieties of sugarcane used in the study were Co62175, NCS005, NCS004 and AND NCS003 and the treatments were laid out in Randomized Complete Block Design (RCBD) replicated three times. The statistical analysis was done using Analysis of Variance (ANOVA) and means were separated with LSD (Least Significant Difference) at $p < 0.05$. Results after statistical analysis showed that there were significant differences between the varieties of the sugarcane with respect to the cane-weight and yield for both wet and irrigated seasons. During the wet season, the values of cane weight per plot ranged from 1.35 kg to 0.48kg plot⁻¹. NCS005 had the highest cane weight value of 1.35 kg plot⁻¹ while the lowest value was obtained from NCS003 (0.48kg plot⁻¹). This was also reflected in the yield which ranged from 9.74 ton/ha to 4.11 ton/ha with NCS005 having the highest (9.74 t/ha) and NCS003 the lowest (4.11 t/ha), suggesting close relationship between weight of cane and yield. The application of NPK 20:10:10 fertilizer also increased the dry matter components of the plant cane and which were found to be significant in % sucrose, % glucose, total sugar and crude fibre. The highest % sucrose, % glucose and total sugar was obtained from Co6215, while the lowest was obtained

from NCS003. Crude fibre percentage was also found to be significantly different among in the four varieties at $p<0.05$ level with the highest obtained in NCS003 and Co6215. The same trend was obtained under the irrigation in 2001 cropping season. In conclusion, the application of NPK fertilizer increased sugar concentration and sugar-cane yield for NCS005 and Co6215 compared to NCS003 and NCS004 varieties

Keywords: Sugarcane; NPK 20:10:10 fertilizer; Dry matter; Sugarcane -Yield, Nigeria

1. INTRODUCTION

Sugarcane belongs to the genus *Saccharum* L. of the tribe Andropogoneae in the grass family (Poaceae) and the most importance source of cane-sugar (Derr. 1949; FAO 2004; Sreenivasan et al.1987). The stems are the main target of cultivation from which sugar is extracted (Daniels & Roach 1987; D'Hont et al. 1996; Mackintosh, 2000; Bakker 1999). It is widely grown throughout the tropical and sub-tropical regions of the world. It inversely depletes the soil of its major nutrients hence there is need to constantly supply supplementary nutrients to the soil under cultivation in order to sustain and replenish the lost nutrients and to increase the yield tonnage of the plant. Although, Sugarcane is an important sugar crop in Nigeria, the rate of consumption of sugar in Nigeria is extremely high but the production is very low (Oworu, 1985). And This makes Nigeria imports about 93% of its sugar requirement from countries that produce sugar in commercial sale and this gulps millions of Naira from the country's foreign reserve (Oworu, 1985). The plant nutrients which are vital to the growth of sugarcane comprises of the major elements: N,P, and K, others are Iron (Fe), Magnesium (Mg) and Calcium (Ca),which are supplied in assimilable form by the gradual soil transformation, which occur at a rate sufficient to provide other nutrients for the need of the plant. It has been proved by Weier et. al (1996) that Phosphorus, Potassium and especially Nitrogen were used at a higher rate by the plant than

63 what the soil can generate (Barnes, 1954). These nutrient elements have been found to have
64 different effects and performance on the growth and development of the sugarcane.
65 Phosphates stimulate the rooting and tillering of the plant while potassium is essential for the
66 synthesis of sugar in the leaf, with movement to the storage cells in the stem (Barnes, 1954,
67 Freyney et al. 1994; Bull, 2000). Researchers such as Humbert (1968) reported that nitrogen fertilizer
68 use increased the attainable tonnage of sugar (Humbert, 1968). Nitrogen was found to increase the
69 sugar tonnage of the crop (Humbert, 1968). Also, According to Lakshmi, et al., 2003 application
70 of the recommended dose of fertilizer (150 kg ha⁻¹) in two equal splits either at planting and
71 within 30 days after planting (DAP) or at 30 and 60 DAP benefited the crop so that more
72 millable canes were produced at harvest which ultimately resulted in increased cane and sugar
73 yield. Application of N in splits increased the fertilization program cost, but its use was justified
74 by increased sugar yield (Obreza and Pitts, 1998; Iftikhar et al 2000 and 2005; Weier et al. 1996;
75 Freyney et al. 1996 ;Bohl et al. 2000).
76 Sugar is a very important dry matter of Sugarcane. The principal components of dry matter in
77 sugarcane include: total sugar, sucrose, reducing sugar (i.e glucose and fructose) and crude
78 fibre (Lingle and Irvine, 1994; Kang et al; 1983). It has also been noted that the amount of sugar
79 stored by different sugarcane varieties and clones depend on the size and efficiency of the
80 photosynthetic system, ability of the sugarcane to translocate, the size of the storage tissues
81 and partition of the photosynthetes for growth and storage (Oworu, 1988; Iftikhar et al 2000).
82 Sucrose stored in the sugarcane decreases relative to low soil fertility and soil moisture
83 (Loehwin, 1953; Clement, 1959). Fibre is an important component of dry matter because of its

inverse relationship to juice extraction. Breaux (1972) reported that sugarcane varieties with low sucrose concentration have high fibre content.

In lieu of this, a study was carried out to determine the effect of NPK (20:10:10) fertilizer on the weight of cane, yield and dry matter components of different sugarcane varieties (*Saccharum officinarum* L), in order to identify the variety that can be greatly influenced by the NPK fertilizer to increase sugarcane tonnage in the country.

2.0 Materials and Methods

Characterization of the Study Area:

The study was carried out as field experiments. The field trials were conducted in 2000/2001 cropping seasons at the Teaching and Research Farm of Olabisi Onabanjo University, Ago-Iwoye (Latitude N 06° 47'; Longitude 03° 58'E) (longitude 03° 58'E, latitude 06° 47'N).

Weather data :

The mean monthly temperature of 27.6°C. Climate of this area is typical tropical lowland rainforest, with the raining season starting about March and ending in November, followed by dry season. The mean annual rainfall is 1506mm and the growing period of 270 days.

Soil Analysis:

The soils of the study area are well drained. The dominant parent material is basement complex rock, with the chemical properties such as slightly acidic, low organic matter content, very-low CEC owing to predominance of kaolinite in their clay fraction, low inherent fertility status and high base saturation which cannot adequately support sugarcane production. The soil characteristic of the experimental site is sandy loam in texture (Table 1).

Table 1: PRE- PLANTING SOIL ANALYTICAL RESULTS

Soil properties	Values
pH (H ₂ O)	5.6
Organic carbon (g kg ⁻¹)	2.11
Total Nitrogen (g kg ⁻¹)	0.30
Available P (mg kg ⁻¹)	0.06

Exchangeable Ca (cmol kg ⁻¹)	0.30
Exchangeable Mg (cmol kg ⁻¹)	0.31
Exchangeable Mn (cmol kg ⁻¹)	72.10
Exchangeable K (cmol kg ⁻¹)	0.03
Exchangeable Na (cmol kg ⁻¹)	0.74
Sand (g kg ⁻¹) %	670
Silt (g kg ⁻¹) %	170
Clay (g kg ⁻¹) %	160

Field Trial

Four varieties of sugarcane were used for the study namely used in the study were: Co62175, NCS 005, NCS 004 and NCS 003 (where NCS means National Cereal Sugarcane). The experiment was laid out in a Randomized Complete Block Design (RCBD) design with three replicates. The experiment was laid out using a Randomized Complete Block Design (RCBD) and replicated three times. The total land area used was 8m by 11m (88m²), with plot size of 2m by 2m with 1m alley way between the plots. Setts of sugarcane of 18cm in length with at least 2 auxiliary buds treated with furadam (fungicide) as seed dressing were planted in the furrows at an angle of 45° with one cuttings per stand at a spacing of 90 x 90 cm and spacing between furrows was 1.5m apart. The first weeding was carried out 3 Weeks after Planting (WAP) and followed by subsequent ones at 6 and 8 weeks respectively. The choice of compound fertilizer NPK 20:10:10 was based on the fact of readily available input within the reach of sugarcane farmers, that will make use of the results to improve their sugarcane production. Basal application of NPK fertilizer (20:10:10) was carried out at 6 weeks, at a recommended rate of 112 Kg NPK/ha. Rodents attack on the crop was prevented by use of traps and clearing of the surrounding bushes about 1m away. Diseases infestations were also controlled. The sugarcane was harvested at maturity (12 months). Data were collected on cane weight, yield and dry matter

components (i.e. % **fw of** Sucrose, Total sugar, Reducing sugars and Crude fibre) **using**
crystallization method. The data were **later** subjected to 2 ways **of** analysis of variance
(ANOVA) and means separated using Least Significant Difference (LSD) at $P \leq 0.05$.

3.0 Results and Discussion

~~**PRE-PLANTING SOIL ANALYSIS:** The result of the pre-planting soil analysis (to affirm the soil
conditions) is presented in Table 1.~~

3.1a. Response of the sugarcane varieties to NPK fertilization during the wet season 2000

The response of the cane-weight and yield of sugarcane (*Saccharum officinarum* L) to NPK
fertilization are shown below in Figure 1, 2.

The application of NPK (20:10:10) Fertilizer showed significant differences between the
sugarcane varieties in terms of cane-weight and yield. The values of cane weight ranged from 0.48
to 1.35 kg/plot. ~~The values of cane weight ranged from 1.35 to 0.48 kg/plot.~~

NCS 005 had the highest value of 1.35 kg while the lowest was obtained from NCS 003 (0.48kg)
(Figure 1). The same result were recorded for sugar-cane yield and it ranged from 4.11 ton/ha to 9.74
ton/ha.

~~This result reflected in the yield of the sugar cane which ranged from 9.74 t/ha to 4.11 t/ha.~~

The NCS 005 had the highest yields of 9.74 ton/ha while the lowest value was from NCS 003
(4.11 ton/ha) (Figure. 2), suggesting a close relationship between the cane weight and yield of
the sugarcane. The study carried out by Lakshmi *et al.*, 2003 corroborated this findings, where
application of the recommended dose of fertilizer (150 kg ha⁻¹) in two equal splits, either at planting
and within 30 days after planting (DAP) or at 30 and 60 DAP benefited the sugarcane crop so that
more millable canes were produced at harvest which ultimately resulted in increased cane and

sugar yield. Also, the findings of Obreza and Pitts, 1998 showed that application of N₂ in splits slightly increased the cane –weight , but its use was justified by increased sugar yield.

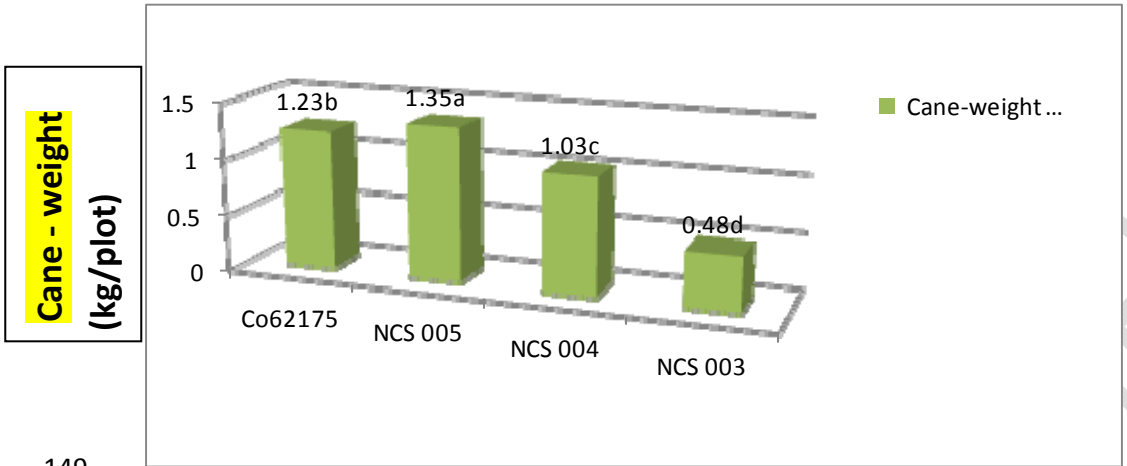


Figure.1: Effect of NPK (20:10:10) Fertilizer on Cane-weight of different sugarcane varieties (*Saccharum officinarum* L.) during the wet season in South-western Nigeria.

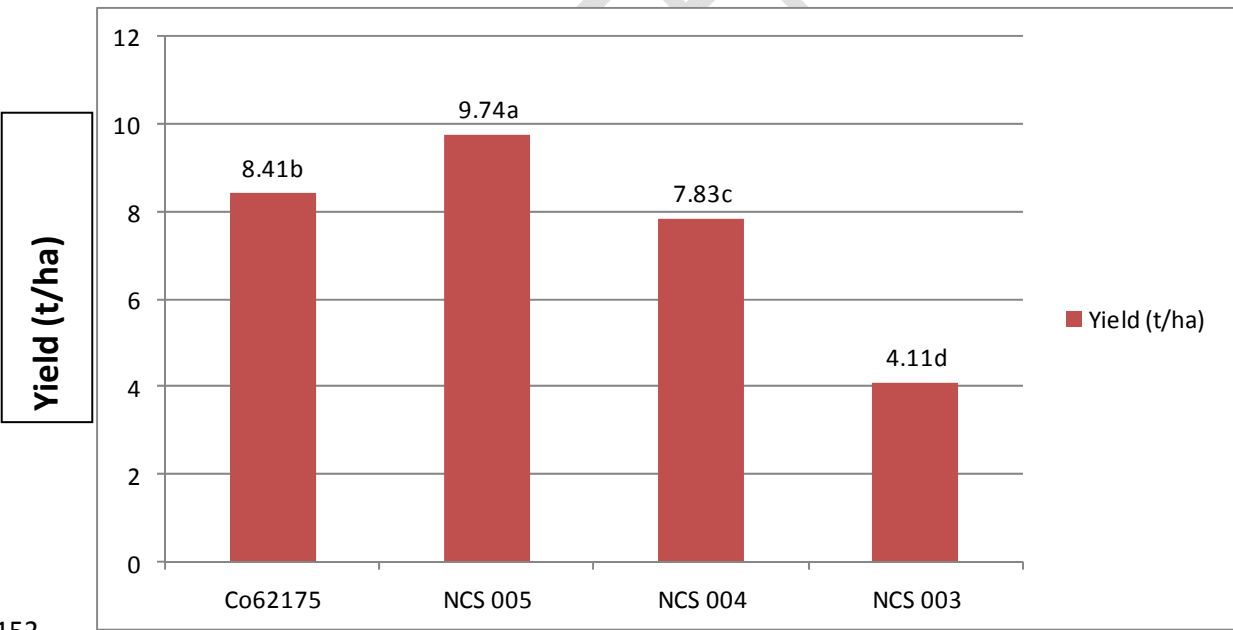


Figure 2: Yield response of different sugarcane varieties (*Saccharum officinarum* L.) to NPK Fertilizer (20:10:10) during the wet season in South-Western Nigeria.

3.1b Response of the dry matter components of the sugarcane varieties to NPK fertilization

The response of the dry matter components to NPK 201010 fertilizer is shown in the Table 1 below.

There were significant differences between the varieties for the dry matter components (% fw of sucrose, glucose, total sugar and crude fibre) except in % fw of Fructose (Table 1). The value of % fw sucrose ranged from 6.83 for variety Co62175 to 2.73 for variety NCS 003 (Table 1). Similar results were obtained for % fw of glucose, fructose and total sugar. Highest value of % fw glucose (2.33) was obtained for Co62175 and lowest value of 0.55 in the NCS 003 (Table 1) while for % fw of fructose, highest value was also recorded in variety Co62175 with 1.27 and lowest value of 0.39 was obtained in the NCS 003 (Table 1). This result corroborated the findings of Iftikhar et al., 2005 and Iftikhar et al., 2000; Bull, 2000)

The value of % fw total sugar ranged from 12.61 for variety Co62175 to 7.81 for NCS 003 variety (Table 1). Conversely, the % crude fibre values ranged from 9.34 for variety NCS 003 to 2.61 for variety Co62175 (Table 1).

Table 1: Dry Matter Components of Four (4) Varieties of Sugarcane (*Saccharum officinarum* L.) as Influenced by NPK fertilizer (20:10:10) during the wet season in South-western Nigeria.

Varieties	% fw Sucrose	% fw Glucose	% fw Fructose	% fw Total Sugar	% Crude Fibre
Co62175	6.83a	2.33a	1.27a	12.61a	2.61d

NCS 005	5.75b	2.07b	1.25b	10.98b	4.74b
NCS 004	4.93c	1.40c	1.20c	10.66c	4.01c
NCS 003	2.73d	0.55d	0.39d	7.81d	9.34a
LSD (0.05)	1.680	1.780	1.753	2.225	2.063
CV (%)	7.64	20.43	25.07	7.02	9.27
	"Xx"	"Xx"	NS	"Xx"	"Xx"
		xx		xx	xx

"Xx" = highly significant, NCS – National Cereal Sugarcane hybrid, NS = Not significant.

Fw = fresh weight

3.2. Response of the four varieties of sugarcane to NPK fertilization under irrigation

The results of the dry matter, cane weight and yield of sugarcane (*Saccharum officinarum* L) under irrigation are shown below in Table 2, Figure 3 and 4 respectively. The same trend that was observed under wet season was recorded during the irrigation.

The values of cane weight ranged from 0.70 to 1.75 kg/plot. NCS 005 had the highest value of 1.75 kg while the lowest was obtained from NCS 003 (0.70kg) (Figure 3). The same result was recorded in the yield of the sugar-cane which ranged from 3.95 to 10.1 ton/ha. The NCS 005 had the highest yields of 10.1 ton/ha while the lowest value was from NCS 003 (3.95 ton/ha) (Figure 4). There was significant differences between the varieties in terms of cane-weight and yield to the application of NPK (20:10:10) Fertilizer.

Also, there were significant differences between the varieties for all the dry matter components (% fw of sucrose, glucose, total sugar and crude fibre) except % in fw of Fructose (Table 2). The value of % fw sucrose ranged from 7.15 for variety Co62175 to 3.70 for variety NCS 003 (Table 2). Similar results were obtained for % fw of glucose, fructose and total sugar. Highest value of % fw glucose (3.40) was obtained for Co62175 and lowest value of 1.23 in the NCS 003 (Table 2) while in the % fw of fructose, highest value was also recorded in variety Co62175 with 2.21 and lowest value of 1.03 was obtained in the NCS 003 (Table 2). (Iftikhar et al., 2005 and Iftikhar et al., 2000; Bull, 2000)

The value of % fw total sugar ranged from 12.90 for variety Co62175 to 8.41 for NCS 003 variety (Table 2). Conversely, the % crude fibre values ranged from 9.63 for variety NCS 003 to 3.14 for variety Co62175 (Table 2).

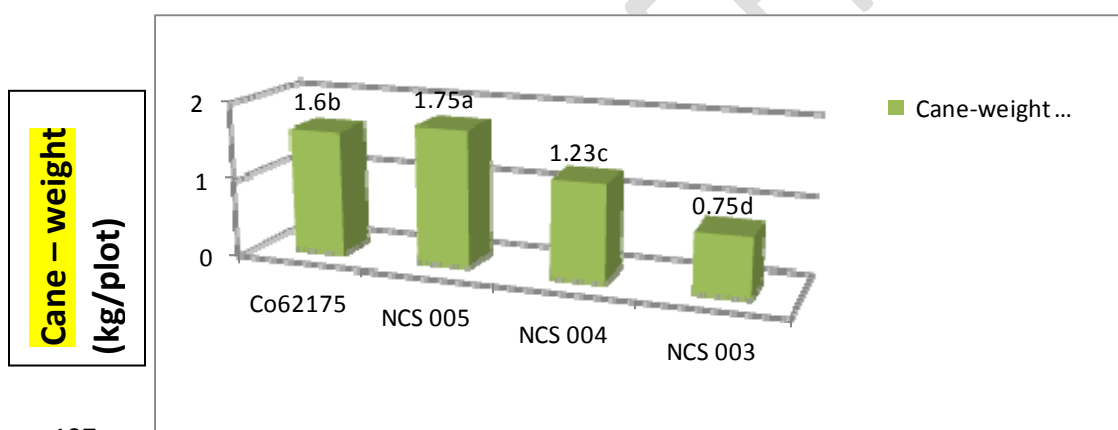


Figure 3: Effect of NPK (20:10:10) Fertilizer on Cane-weight of different sugarcane varieties (*Saccharum officinarum* L.) under irrigation in South-western Nigeria.

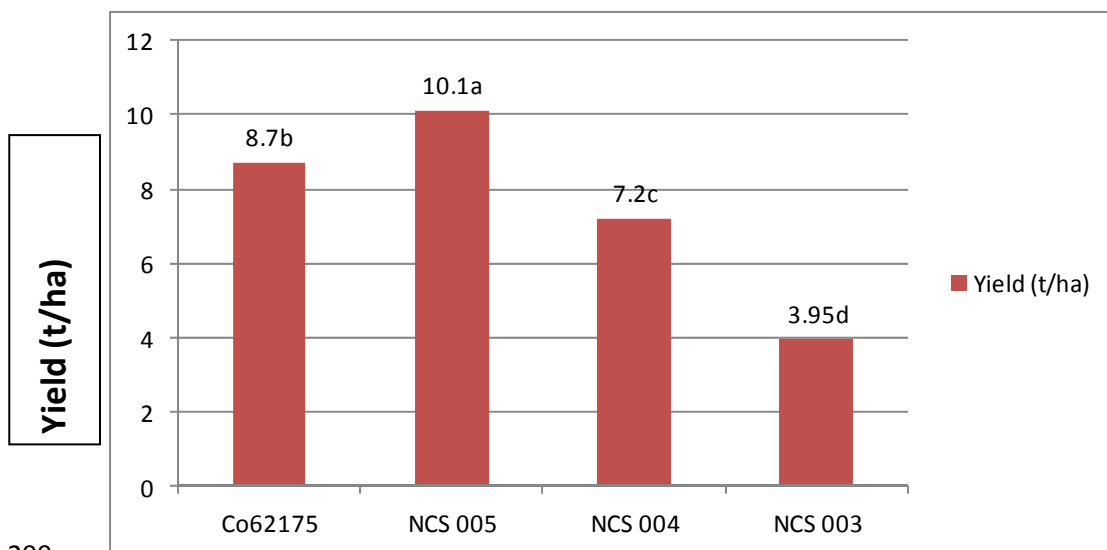


Figure 4: Yield response of different sugarcane varieties (*Saccharum officinarum* L.) to NPK Fertilizer (20:10:10) under irrigation in South-Western Nigeria.

Table 2: Dry Matter Components of Four (4) Varieties of Sugarcane as Influenced by NPK fertilizer (20:10:10) under irrigation in South-western Nigeria.

Varieties	% fw Sucrose	% fw Glucose	% fw Fructose	% fw Total Sugar	% Crude Fibre
Co62175	7.15a	3.40a	2.21a	12.90a	3.14d
NCS 005	6.50b	3.12b	2.13b	10.24b	4.81b
NCS 004	5.12c	2.40c	2.06c	9.78c	4.25c
NCS 003	3.70c	1.23d	1.03d	8.41d	9.63a
CV (%)	XX	XX	NS	XX	XX

“xx” = highly significant, **NCS** = National Cereal Sugarcane hybrid, **NS** = Not significant.

4. Conclusion:

The results obtained from the study showed that application of 112kg NPK/ha Fertilizer increased the cane -weight, yield and improve the dry matter components of the sugarcane (*Saccharum officinarum* L.) depending on the varieties of the cane. It also affirmed that varieties Co66175 and NCS005 gave more sugar concentration and yield respectively in response to NPK (20:10:10) fertilizer when compare to NCS 004 and NCS 003. Also, it showed that NCS 003 gave the highest crude fibre content than the other varieties. Conclusively, incorporation of these two varieties (Co66175 and NCS005) into commercial sugarcane production in Nigeria will increase the sugar tonnage in the country

COMPETING INTERESTS

Authors have declared that no competing interests exist

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