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Changing Pattern in Sweet Potato Cultivation in Semi-Arid Environment, Nigeria

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ABSTRACT: Sweet potato, an herbaceous perennial vine is a sweet tasting tuberous root vegetable. Its importance lies on its sweetness and nutritional value. The varieties ranged from wild accessions to farmer varieties. In this study, thechanging pattern in sweet potato cultivation in the semi-arid environment in Nigeria is examined. Questionnaire was administered to 450 respondents from 15 agricultural settlements in 15 local governments in the study area, using clustered sampling technique. Data was analyzed using frequency counts, percentage and pairwise t-test. Results show twenty-seven varieties of sweet potatoes were cultivated in the basin, with 19 varieties planted in 1970's and 24 varieties cultivated in 2000's. Farmers no longer plant 3 varieties while 8 varieties were newly introduced. The farmers planting these varieties ranged from 0.2% to 20%. The planting of 7 varieties have reduced while there is an increase in the planting of 9 varieties. White sweet potato was the most popular and widely planted varieties, accounting for 18% and 20% in the 1970's and 2000's respectively. Factors that determine choice of the varieties planted include farmers' choice of sweet potatoes is determined by nutritional value, skin colour, flesh colour, taste, size, personal preference, market value, demand, yield, appearance as well as resistance to pests and diseases. Farmers cultivating sweet potatoes in the basin have increased by 1.4% from 82.3% in 1970's to 83.7% in 2000's. Pairwise t-test showed that there is no significant difference in sweet potatoes varieties cultivated between 1970's and 2000's.

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The sweet potato (*Ipomoea batatas*), an important sweet tasting tuberous root vegetable, is a dicotyledonous plant that belongs to the family Convolvulaceae (Purseglove, 1991). It is only distantly related to the potato (*Solanum tuberosum*). It has about 50 genera and more than 1,000 species. The sweet potato gene bank maintained at International Potato Center (CIP) contains 5,526 cultivated accessions from 57 countries (Huaman and Zhang, 1997). According to International Potato Center, there are about 6,500 sweet potato varieties world-wide, including wild accessions, farmer varieties, and breeding lines. Some varieties are poisonous. The species called wild sweet potato vine, man root, or man-of-the-earth is not edible, but it is cultivated as an ornamental vine (Bourke and Vlassak, 2004). Sweet potatoes are native to the tropical parts of South America and were domesticated there at least 5,000 years ago (Austin, 1988). Austin maintained that the center of origin of sweet potatoes was between the Yucatán Peninsula of Mexico and the mouth of the Orinoco River in Venezuela It spread from this area by the local people to the Caribbean and South America by 2500 BC. Sweet potato has been radiocarbon-dated in the Cook Islands in Polynesia to 1000 AD, and current thinking is that it was brought to central Polynesia 700 AD, possibly by Polynesians who had traveled to South America and back, and spread across Polynesia to Hawaii and New Zealand from there. Sweet potatoes are now cultivated throughout tropical and warm temperate regions wherever there is sufficient water to support their growth. Sweet potatoes are smooth skin with different shapes and sizes. The colour is in various shades of creamy white, white, yellow-orange, Medium Orange, Burnt Orange, Purple Red, Pink-Red, Copper, brilliant Copper, tan, Cream-Tan, Rose-pink, brown and reddish-purple, purple and red. Its flesh colour is in shades of orange, Light Orange, Dark Orange, Deep Orange, yellow-orange, Yellow-Greenish (cooked), Orange Mottled, white, purple and red (Edmond and Ammerman, 1971; Woolfe, 1992; Bourke and Vlassak, 2004; USDA, 2001). Pink, yellow and green varieties are high in carotene, the precursor of vitamin A. China is the largest grower of sweet potatoes, providing about 80% of the world's supply; 130 million tons were produced in 1990. According to the Food and Agriculture Organization (FAO) statistics, world production in 2004 was 127,000,000 tonnes. The majority comes from China, with a production of

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105,000,000 tonnes from 49,000 km^2. In 2009, China was the largest producer of sweet potato with 80.5%. Nigeria followed as the second largest producer with 3.3%. Others include Uganda with 2.7%, Indonesia with 1.88%, Vietnam with 1.32, Tanzania with 1.31%, India with 1.1% and Japan with 1.0%. About 20,000 tonnes (20,000,000 kg) of sweet potatoes are produced annually in New Zealand, where sweet potato is known by its Māori name, *kūmara*. In the U.S., the states of North Carolina, California, Louisiana and Mississippi produced over 95% of the U.S totals. These states produced 38.5%, 23%, 15.9%, and 19% respectively. Per-capita production of sweet potatoes in the world is greatest in Papua New Guinea with 550 kg per person per year. This is followed by Solomon Islands with 160 kg, Burundi and Rwanda with 130 kg and Uganda with 100 kg. In these countries, sweet potatoes are staple food. The average per capita consumption of sweet potatoes in the United States is only about 1.5–2 kg (3.3–4.4 lb) per year, down from 13 kg (29 lb) in 1920 while it is 7 kg (15 lb) per year in New Zealand (Hartemink *et al.*, 2000; Bourke and Vlassak, 2004). A number of studies exists on sweet potatoes in Nigeria (Odebode *et al.,* 2008; Ezeano, 2010), Kassali, 2011; Ahmad *et al.,* (2014). Odebode *et al.,* 2008 studied the promotion of sweet potato for the food industry in Nigeria. Ezeano (2010) examined the sweet potato production, consumption and utilization among households in southeastern Nigeria. Kassali (2011) determined the economics of sweet potato production. Ahmad *et al.,* (2014) studied the efficiency of sweet potato farmers in Nigeria: Potentials for food security and poverty alleviation. Despite these researches, the study on the changing pattern in sweet potatoes cultivation in the semi-arid environment with particular reference to Sokoto-Rima River Basin, Nigeria is yet to be carried out. This study intends to fill the gap created by dearth of literature in the study area. In this study, an attempt is made at assessing the changing pattern in sweet potato cultivation in the semi-arid environment, Nigeria.

MATERIALS AND METHODS

Study Area: The study area lies between latitude 10.8^o N and 13.58^{o}N and longitude 3.30^o E and 7.13^o E (Figure 1). It exhibits a tropical climate, with a definite and marked wet and dry season. The tropical maritime air mass dominates the entire basin during the wet season, whereas the tropical continental (cT) air mass predominates during the dry season. The wet season is from May to September in the southern part and June to October in the north (Bello, 1996; Iliya and Kwabe, 2000; Mamman, 2000a, b; Adejuwon, 2012).

The pattern of rainfall in Sokoto-Rima Basin reflects the seasonal variation of the surface location of the ITD. Annual rainfall is single maxima and varies from about 1013 mm in the southern part to about 650mm in the northern part (Adejuwon, 2012). The rainfall decreases in both duration and amount from the south northward.

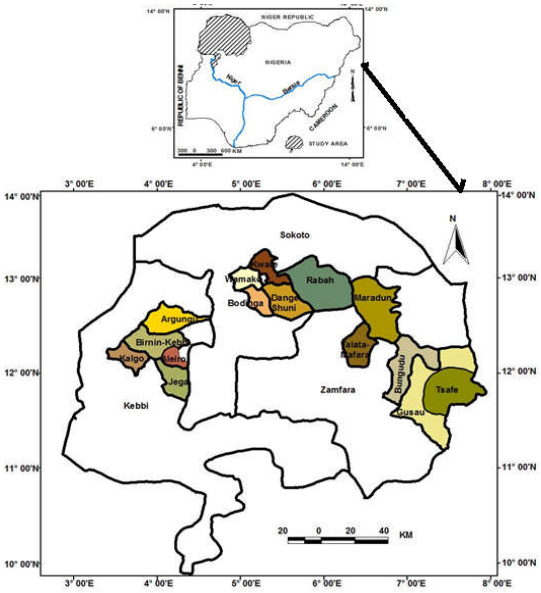

Fig 1: Selected local governments where questionnaire was administered

The humidity of the wet season is high reaching an average of 80% in the southern area but lower to about 30% in the dry season and a mean value of 20 or 25% in January and April (Adejuwon, 2017). Diurnal values may fall from 50% at dawn to 10% in the afternoon. This is feature of the harmattan when the dry and dust-laden North East trade winds are blowing from the Sahara under cloudless but dusty conditions. The harmattan is marked by very cold temperatures and a thick fog (Adejuwon 2016). Sokoto-Rima Basin experiences high temperatures all the year round. The mean annual temperature is 34.5^{o}C while the mean annual temperature range is between 5^{o}C and 10^{o}C ((Emielu, 2000; Adejuwon, 2015). The highest temperatures are normally in hot season, March to April while the minimum temperatures are usually recorded in January to February.

Data Collection and Analysis: The data used in this study is basically primary data. Clustered sampling technique was employed in collecting data in the field. 450 respondents were sampled from 15 agricultural settlements in 15 local governments in the study area in 2009 (table 1). Thirty copies of research questionnaires were administered in each settlement. Data was analyzed using descriptive frequency counts, percentage and pairwise t-test with Statistical Package for Social Sciences (SPSS Version 16).

RESULT AND DISCUSSION

Sweet potatoes are an important sweet tasting tuberous root vegetable consumed worldwide (Hartemink *et al.*, 2000; Bourke and Vlassak, 2004; FAO, 2004). It is an herbaceous perennial vine of the Convolvulaceae family (Purseglove, 1991). Sweet potatoes are in various shades of creamy white, white, yellow-orange, burnt orange, pink-red, copper, tan, cream-tan, rose-pink, purple, red etc.; its flesh colour is in shades of orange, light orange, dark orange, deep orange, yellow-orange, yellow-greenish (cooked), orange mottled, white, purple and red; and has many varieties, which vary in size and shape (Edmond and Ammerman, 1971; Woolfe, 1992; Bourke and Vlassak, 2004; USDA, 2001).

Table 1: The states, local governments and communities where data were sourced in Sokoto-Rima River Basin

State	Local Government	Communities
Sokoto	Wamakko	Gumbi
	Bodinga	Mil Goma
	Kware	Durbawa
	Dange Shuni	Dange
	Rabah	Maikujera
Kebbi	Kalgo	Kalgo
	Birni-Kebbi	Gulumbe
	Aliero	Dakala
	Jega	Basaura
	Argungu	Alwasa
Zamfara	Talata Mafara	Tunfafiya
	Gusau	Madidi
	Maradun	Dosara
	Bungudu	Tazame
	Tsafe	Tsafe

As shown in table 2, there are 27 varieties of sweet potatoes planted in Sokoto-Rima River Basin, with 19 varieties planted in 1970's and 24 planted 2000's. Three varieties are no longer planted while 16 varieties were retained. The farmers that planted sweet potatoes increased slightly from 82.3% in 1970's to 83.7% in 2000's. In the 1970's, white sweet potatoes (Fari Dankali) – 18%, yellow sweet potato (Ja Dankali) – 13.4% and Bahaushe variety - 8.6% , which accounted for 40% of the sweet potatoes cultivated were the most popular and widely planted varieties in Sokoto-Rima River Basin.

Harshensa, Dan Bakalori, Dan Kudaku, Dankwai, Kunnen Kura, Dan Zafi, Dan Eka and Riyadi varieties which varied from 4.2% to 5.1% were also popular. In 2000's, white sweet potatoes (20%) and Bahaushe (10.4%) variety are the most popular and widely planted varieties. The reason for preferring white sweet potatoes to other varieties by the majority of the farmers was as a result of market value, demand, colour and taste. The planting of yellow sweet potatoes reduced by 12.1% from 13.4% to 1.3% in favour of white sweet potatoes, Bahaushe, Toris, Yansa varieties, but is still being planted because of personal preference, colour, market value and consumer demand. Yellow sweet potatoes reduced because farmers discovered other varieties that were preferable. Dakantanun, Sobo and Gajeren Idima that were planted by few farmers in the past no longer exist while Kwate, Dankali Turawa, Karas, Chadi, Garo-garo, Ruwan Kudi, Yarga and Gulbi varieties with a range of 0.2% to 1.1% that were newly introduced varieties have not gained much recognition among farmers. The introduction of new varieties which are found to be better displaces the old varieties.

This study revealed changes in the planting of sweet potato varieties in Sokoto-Rima River Basin. Dankwai, Eka, Riyad, white sweet potatoes , Bahaushe, Zafi, Laina, Toris and Yansa varieties increased by 0.3% to 5.1% while Lauro, Baku, Harshensa, Kudaku, Bakalori, Kunnen Kura and yellow sweet potatoes decreased by 0.2% to 12.1% (Table 3). Toris and Dan Yansa are the most increasingly planted varieties while Ja Dankali reduced drastically from 13.4% to 1.3%. Farmers' choice of sweet potatoes is determined by nutritional value, skin colour, flesh colour, taste, size, personal preference, market value, demand, yield, appearance as well as resistance to pests and diseases. The nutritional value of raw sweet potato energy, Carbohydrates (Starch, Sugars and Dietary fiber), Fat, Protein, Vitamin A equiv., beta-carotene, lutein and zeaxanthin, Thiamine (Vit. B1), Riboflavin (Vit. B2), Niacin (Vit. B3), Pantothenic acid (B5), Vitamin B6, Folate (Vit. B9), Vitamin C, Vitamin E, Calcium, Iron, Magnesium and Phosphorus (USDA Nutrient Database, 2001).

The peptic substance present in fresh tubers contains uronic acid and methoxyl. Other constituents include phytin, two monoaminophosphatides (probably lecithin and cephalin), organic acids (oxalic acid), phytosterolin, phytosterol, resins, tannins, and coloring matter. The Centre for Science in Public Interest (1992) compared the nutritional value of sweet potatoes to other vegetables using fiber content, complex carbohydrates, protein, vitamins A and C, iron, and calcium as a yardstick, noted that sweet potatoes ranked the highest in nutritional value. However, pink, yellow and green varieties are high in carotene, the precursor of vitamin A. A variety cultivated in a particular locality may change as people come in contact with more preferred variety. For example, In pre-European days the Māori in New Zealand used the small, yellow, skin finger size sweet potatoes (kumara) known as Taputini, they had brought with them from east Polynesia.

Table 2: Sweet Potato varieties planted in Sokoto-Rima River Basin

N/S	Varieties	Planted in the 1970's		Planted in 2000's	
		Number of Respondents	Percentage	Number of Respondents	Percentage
1	Harshensa	23	5.1	21	4.7
2	Bahaushe	39	8.6	47	10.4
3	Dan Bakalori	22	4.9	13	2.9
4	Dan Kudaku	26	5.6	18	4
5	Dankwai	21	4.6	22	4.9
6	Kunnen Kura	21	4.7	10	2.2
7	Yellow sweet potatoes (Ja Dankali)	55	13.4	6	1.3
8	White sweet potatoes (Fari Dankali)	85	18	92	20
9	Dan Zafi	19	4.2	25	5.6
10	Dan Eka	21	4.7	26	5.8
11	Dan Baku	6	1.3	5	1.1
12	Lauro	4	.9	1	.2
13	Laina	1	.2	7	1.6
14	Riyadi	20	4.4	25	5.5
15	Toris	1	.2	24	5.3
16	Dan Yansa	1	.2	24	5.3
17	Dakantanun	2	.4	-	-
18	Sobo	3	.7	-	-
19	Gajeren Idima	1	.2	-	-
20	Dankali Turawa	-	-	2	.4
21	Karas	-	-	2	.4
22	Dan Chadi	-	-	1	.2
23	Dan Garo- garo	-	-	1	.2
24	Dan Ruwan Kudi	-	-	1	.2
25	Dan Yarga	-	-	1	.2
26	Dan Kwate	-	-	5	1.1
27	Dan Gulbi	-	-	1	.2
Total		371	82.3	380	83.7

Table 3: Differences in the percentage of farmers' planting sweet potatoes varieties in Sokoto-Rima River Basin

N/S	Varieties	Planted in the 1970's	Planted in 2000's	Percentage Difference
		Percentage	Percentage	
1	Harshensa	5.1	4.7	-0.4
2	Bahaushe	8.6	10.4	1.8
3	Dan Bakalori	4.9	2.9	-2.0
4	Dan Kudaku	5.6	4	-1.6
5	Dankwai	4.6	4.9	0.3
6	Kunnen Kura	4.7	2.2	-2.5
7	Yellow sweet potatoes (Ja Dankali)	13.4	1.3	-12.1
8	White sweet potatoes (Fari Dankali)	18	20	2.0
9	Dan Zafi	4.2	5.6	1.4
10	Dan Eka	4.7	5.8	1.1
11	Dan Baku	1.3	1.1	-0.2
12	Lauro	.9	.2	-0.7
13	Laina	.2	1.6	1.4
14	Riyadi	4.4	5.5	1.1
15	Toris	.2	5.3	5.1
16	Dan Yansa	.2	5.3	5.1
17	Dakantanun	.4	-	-
18	Sobo	.7	-	-
19	Gajeren Idima	.2	-	-
20	Dankali Turawa	-	.4	-
21	Karas	-	.4	-
22	Dan Chadi	-	.2	-
23	Dan Garo- garo	-	.2	-
24	Dan Ruwan Kudi	-	.2	-
25	Dan Yarga	-	.2	-
26	Dan Kwate	-	1.1	-
27	Dan Gulbi	-	.2	-
Total		82.3	83.7	

Later, larger varieties introduced from about 1800 by American whalers, sealers and trading vessels quickly predominated. A variety can also be planted because of the importance attached to its industrial use in a particular society. In South America, the juice of red sweet potatoes is combined with lime juice to make a dye for cloth. By varying the proportions of the juices, every shade from pink to black can be obtained. Sweet potatoes or camotes are often found in Moche ceramics (Laco Museum collection, 300 AD). All parts of the plant are used for animal fodder. Besides, a variety can be preferred to the other because of its higher nutritional value.

For example, sweet potato varieties with dark orange flesh have more beta carotene than those with light colored flesh, and their increased cultivation is being encouraged in Africa, where vitamin A deficiency is a serious health problem. Pairwise t-test was used to examine the difference in sweet potatoes varieties between 1970's and 2000's (Table 4). The t-test result is as follows: $t(26) = -0.139$, p 0.05, $CI_{0.95}$ -5.26, 4.59. This means there is no significant difference between 1970's and 2000's as observed during the study period.

Farmers planting sweet potatoes frequently face production problems related to pests, diseases and weeds and abiotic stresses such as nutrient deficiencies and drought that can reduce the yield (Wairegi *et al.,* 2010). The sweet potato virus disease (SPVD) caused by whiteflies and aphids is the most serious sweet potato disease in Africa.

Gibson *et al.* (2004) reported that whiteflies cause sweet potato chlorotic stunt virus while aphids cause sweet potato feathery mottle virus and that the combined effect these SPVD is highly destructive.

Table 4: Pairwise t-test for sweet potatoes planted in 1970's and 2000's in the Sokoto-Rima River Basin

Crop	Paired Differences						
			95% Confidence Interval of the Difference				Significan
	$\bar{X}$	SD	Lower	Upper	T- value	df	t (2-tailed)
Sweet potato	-0.33	12.44	-5.26	4.588	-0.139	26	0.890.

SD = Std. Deviation; $\bar{X}$ = Mean

The greatest pest attacking sweet potatoes globally is the sweet potato weevil (C. *formicarius* complex) (Allemann *et al.,* 2004). Smith (1997) and Stathers *et al.* (2003) noted that the severity of weevil attack depends on variety and delayed harvest. Poor storability of roots is another challenge affecting smallholder sweet potato (Abidin *et al.*, 2016). Low crop yields are usually caused by a multitude of interacting biophysical, socio-economic and management constraints that determine final production on farmers' fields (Fermont *et al.,* 2009).

*Conclusion***:** This study has shown that 27 varieties of sweet potatoes were cultivated, 8 were newly introduced while 3 varieties no longer exists in the study area. The cultivated varieties ranged from 0.2% to 20% and increased from 19 to 24 between 1970's and 2000's. The cultivation of 7 varieties reduced while 9 varieties increased. White sweet potato was the most widely planted variety. The planting sweet potatoes in the basin have increased by 1.4%. This study recommends the cultivation of sweet potato with pink, yellow, green and dark orange flesh that has more beta carotene, the precursor of vitamin A than light colored flesh.

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