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Review

Sugar cane production problems in Nigeria and some Northern African countries

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Sugar cane (*Saccharum officinarum* L.), the tall perennial grass from the family member of the grass family Gramineae, is the major sugar crop from which sugar is produced. Its bye-products have found use in industrial settings of medicine, pharmaceuticals, confectionery and beverages, electricity and motor fuels. The production of this wonderful crop in Nigeria and some Northern African countries is besieged with a number of problems ranging from biotic and abiotic to social and environmental. In spite of these, efforts have continued to be made by sugar cane growers and the governments of these nations with little or no tangible results in Nigeria and with excellent results in Northern African countries in terms of total hectares put to sugar cane production and availability of certification schemes to check excessive and uncontrolled expansion as well as the yield per hectare of millable cane and sugar yield. Common problems militating against increased sugar cane production in Nigeria and Northern African countries like requirement capital, lack of market outlay, biotic and abiotic stresses, high transport and production costs of hauling harvested sugar cane to the mills, low capacity building, lack of sugar cane growers and technologist associations, macro- and micro-environmental issues, lack of legal frameworks and lack of national and regional networking groups are highlighted in this paper. A general lack of political will to enforce stiff legislations on sugar imports is also discussed. Stakeholders in the sugar cane industry in these countries are called upon to initiate proactive measures that will surmount these problems in order to step up sugar cane production.

Key words: Sugar cane, problems of production, biotic and abotic stresses, legal frameworks, Nigeria, Northern African countries.

INTRODUCTION

Sugar Cane (*Saccharum officinarum* L.) is a genus of tall perennial grasses (Family Poaceae, tribe Andropogoneae) and native to warm temperate to tropical regions of the old world. Sugarcane has stout, jointed and fibrous stalks that are rich in sugar and can measure more than 3 meters tall (Bigman, 2001). It has a very high potential for biomass production and has other advantages such as being perennial, adaptable to most types of soil, resistant to most diseases and a guard against soil erosion (Tew, 1980). It is traditionally cultivated and processed for sugar; however it can be envisaged as a multipurpose crop with a potentially important role in integrated industries, biofuel production, electricity, soil fertility and soil improvement (Suheang, 2005, Forum for Agricultural Research in Africa (FARA), 2008; Sielhorst and Veen, 2008). It has also got use in medicine and chemistry (Lewis and Elvin-Lewis, 1977; Duke and Wain, 1981).

Sugar cane is grown in over 200 countries of the world and in 2008; an estimated 1,740 MT of sugar cane was produced worldwide (FARA, 2008). The top producers of sugar cane, in order of production, on a worldwide basis are Brazil, India, China, Thailand, Pakistan and Mexico. The estimates of sugar cane production for 2008 also indicated more than doubling of outputs to 1525 million tons from some 21.9 million hectares harvested sugar cane. In terms of biomass harvested and transported, sugar cane is the world's largest crop . The theoretical maximum yield is 280MT/ha/yr cane and seven countries, excluding Nigeria and Northern African countries, average more than 100MT (FARA, 2008).

Sugar cane is cultivated either under irrigation as in India, Pakistan and Northern African countries of Egypt and Sudan (Abou-Salama (2004), or in rain-fed tropical areas with ample rainfall. Land productivity in areas suitable for its rain-fed production is typically much higher than for cultivated land in cooler climates or arid sub-tropical and tropical agriculture. The crop is found throughout the tropics and subtropics (FARA, 2008). However, large parts of the world cannot grow it for climatic reasons and its impact in climatically suitable areas is therefore more significant. As observed by Lagercrantz, (2006), there is no time like the present to develop social and environmental criteria for the crop's production in all its producing countries of the world and of course Nigeria and Northern African counties inclusive (Smeets *et al*., 2005, 2008).

Whereas there exist both know-how and experienced organizations in place to coordinate proactive sugar cane production in other countries like Brazil and South Africa, such organizations are lacking particularly in Nigeria and or Northern African countries at present. Thus there are a number of identified problems associated with the growing of sugar cane in Nigeria and Northern African countries, although the overall environmental impact cannot be said to be much larger than other produce (Lagercrantz, 2006).

Some of the other specific and general production problems of sugar cane in Nigeria and Northern African countries include high transportation costs (Chethmrongchai *et al*., 2001), biotic and abiotic stresses, infrastructural inadequacy, technical limitations, environmental issues, low capacity building and low skill acquisition as well as lack of efficient technology transfer and development (Makinde *et al*., 2009).

In addition, the rap rush in the biofuels option for greener environment, the problem of vast monoculture associated with sugar cane on the environment already being speculated to exist in Brazil (Van Antwerpen *et al*., 2007, Zuurbier and van de Vooren 2008) may soon exacerbate the existing problems enumerated in this paper. When such additional problems arise, deforestation could precipitate loss and social conflicts caused by displacing agricultural activities elsewhere as well as existing inhabitants.

Concerned with the advent of such would be problems, Quirk *et al*. (2007), reported that an international conference in London in June 2005 confirmed that several producers and processors of sugar cane were committed to the common goal of production and processing of the crop in an environmentally, socially, and economically sustainable manner known as the Better Sugar cane Initiative (BSI). The initiative believes that stakeholders will engage in a constructive dialogue to define and develop relevant performance-based and verifiable standards to describe practices within the value chain for sustainable sugar cane systems. Enforcement of such standards will also foster implementation of improved management practices to effect measurable reduction in key impacts such that might occur with expansive sugar cane production by Nigeria and northern African countries, as there is evidence that more sustainable production practices can result in improved profitability (Quirk *et al*., 2007).

Regrettably, well defined criteria for sugar cane productivity set out to stamp the problems arising from its increased production existing in some African countries such as South Africa are not available in Nigeria particularly and only in few Northern African countries. Such criteria include:

(1) Well organized partnership for sugar cane production.
(2) Acquisition of skilled scientists, researchers, administrations to drive the sugar cane industry objectives in the regions.
(3) Target assistance of identified cane farmer groups to get them convinced of the ratio system in place in the industry and the rules in the industry.
(4) Development and implementation of sustainable interventions projects that can change the socio economic status of cane growers which will in turn support the industry in self financing means such as extension levies.
(5) Establishing synergetic organizations with strong history of good governance and commitment to mitigate problems faced.
(6) Committed governments' policies to develop the sugar cane industry within manageable international competitiveness conditions such as constant review of the sugar acts where they exist (Bigman, 2001).

GENERAL FEATURES OF NIGERIA AND NORTHERN AFRICAN COUNTRIES THAT MAY FAVOUR EXPANSIVE SUGAR CANE PRODUCTION

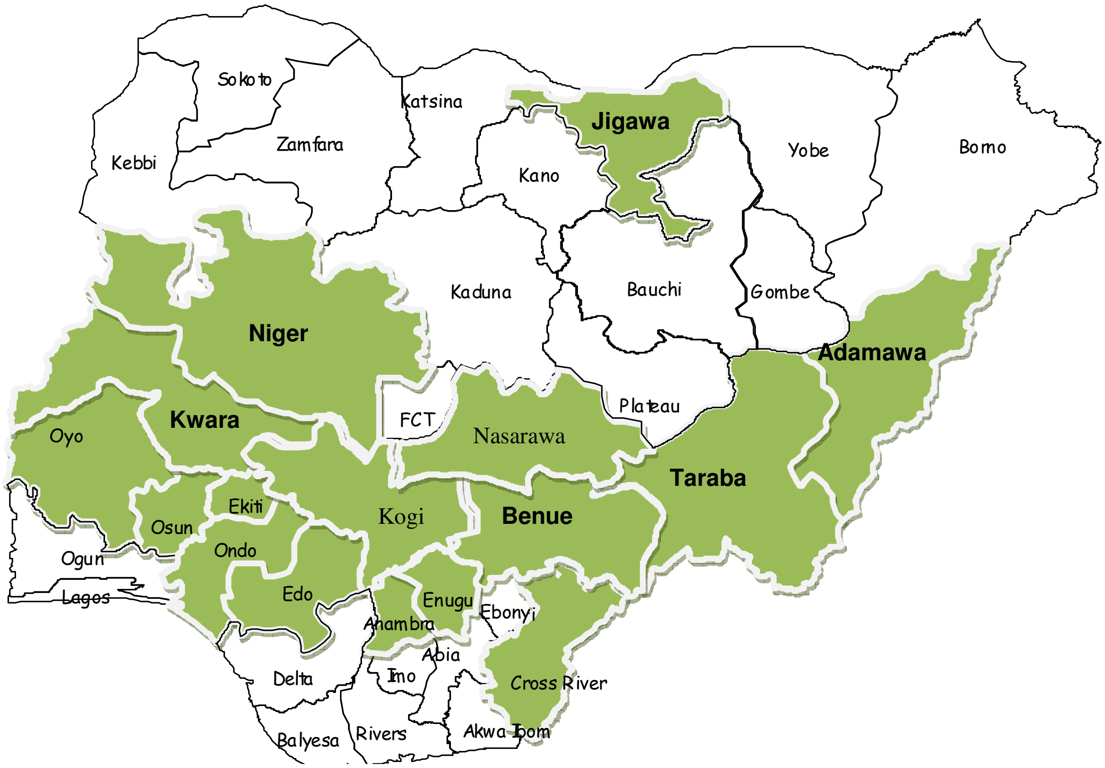

Figure 1. Potential Areas for sugar cane cultivation in Nigeria.

In Nigeria, though the cultivation of commercial sugar cane suffered a serious setback due to the poor performance of the government-owned sugar companies which have been privatized since 2002, there is the huge potential for growing sugar cane on a large scale in the country, particularly along the entire length and breath of the rivers Niger and Benue (Figure 1) Thus, over 800,000ha of land could support high yield sugar cane production in Nigeria. Creation of or building partnership with local business to halt negative impacts on good markets and building local supports for the long term development of the sugar cane industry are being pursued for increased sugar cane productivity.

Africa is the largest and most populous continent in the world after Asia. Covering 20.4% of the available land area worldwide, it is home to over 900 million people distributed over 53 countries (FARA. 2008).

For administrative and other purposes, Africa is divided into five sub-regions under the AU namely:

(a) Eastern Africa (Djibouti, Ethiopia, Somalia, Eritrea, Kenya, Uganda, Tanzania, Comoros, Seychelles, Mauritius, Sudan).
(b) Northern Africa (Algeria, Egypt, Libya, Morocco, Mauritania, Tunisia, Western Sahara).
(c) Western Africa (Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Liberia, Mali, Sierra Leone, Guinea, Guinea Bissau, The Gambia, Senegal, Ghana, Níger, Nigeria, Togo).
(d) Central Africa (Burundi, Cameroon, Chad, Central African Republic, Congo, Democratic Republic of Congo, Gabon, Equatorial Guinea, Rwanda, Sao Tome and Principe).
(e) Southern Africa (Angola, Botswana, Lesotho, Madagascar, Mauritius, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe), (AU/EXP/ STEERING /ST/6(III, 2007).

Despite the continent having about 14% of the world's population and producing 7% of the world's commercial energy, it consumes only 3% of that energy and exports more than half of its production (Dallemand, 2008; Anon, 2008). Access to energy is essential for the reduction of poverty and the promotion of economic growth. Communication technologies, industrialization and agricultural improvement require abundant, reliable, and cost-effective energy access. Energy security and access to energy are also crucial for social improvement, in education and expansion of municipal water systems which are necessary to the building of peace and democracy (FARA. 2008).

Thus, Africa continues to face great challenges; it is still far from achieving the Millennium Development Goals (MDGs). To date around half of Africa's population live in absolute poverty with about 70% depending on traditional biomass as their only source of fuel. The lack of access

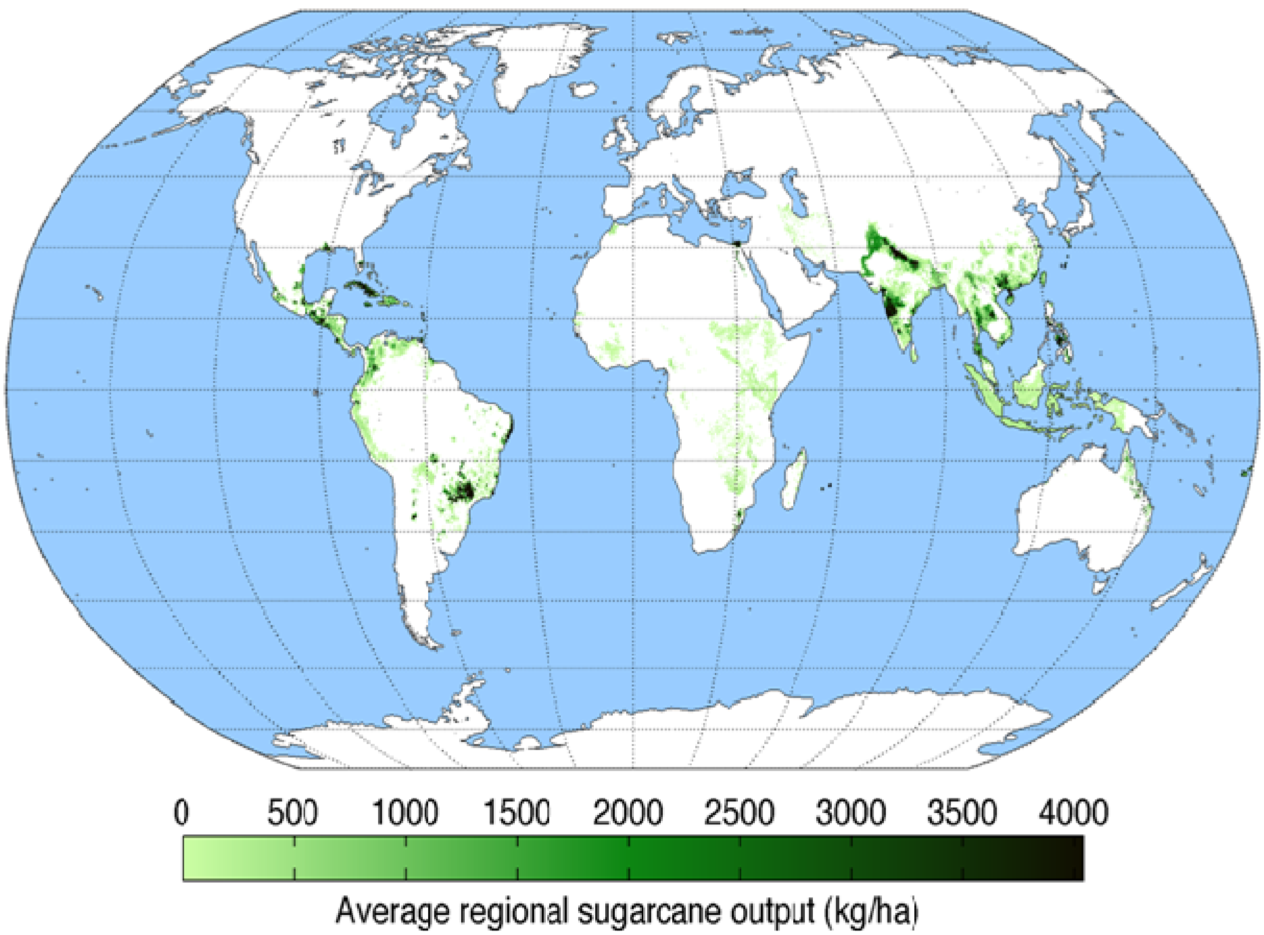

Figure 2. Average regional sugar cane output (kg/ha) Adapted from Bradshaw *et al.*, 2004.

to reliable, clean and affordable energy services in Africa is seriously hampering all efforts for more economic growth and less poverty. It is estimated that, with the exception of South Africa and Egypt, the majority of African countries are only able to provide direct access to electricity to 20% of their peoples. This number is as low as 5% in some countries. Most of the existing power plants and transmission equipment were constructed in the 1950s and 1960s, and in the absence of proper maintenance have deteriorated over the last several decades; the degradation has forced many utility companies as well as sugar estates to operate at small fractions of their installed capacity (FARA, 2008).

In terms of sugar cane production worldwide, Africa's contribution seems quite negligible as seen in (Figure 2). On the surface, apart from South and East Africa, there is hardly any sign on the world map indicating sugar cane producing areas in Nigeria or Northern African countries (Figure 2). North Africa on the other hand, is very diverse from the Western Sahara to Egypt (Figure 3) made up of coastal agricultural grasslands, deserts, mountains, high lands, valleys, basins, rivers, lakes and seas. One major defining feature is the lack of precipitation which gives the region the name 'The Dry World' (Blij and Muller, 2007).

The Western Sahara countries are on the coast of the Atlantic Ocean and the area is made up of humid desert flatlands. Morocco, Tunisia and Algeria which are also known as the Maghareb countries have the Altas Mountains running through them. The presence of the Atlas Mountain explains the high precipitation that results in the availability of their coastal grasslands (Bradshaw *et al.*, 2004). Thus, these areas are some of the only places in North Africa where agricultural activities like sugar cane production succeed.

Tunisia specializes in citrus production while Libya is bounded by deserts and thrives mainly on irrigated agricultural production, while Egypt specializes in basin irrigation, a system where farmers capture and store water in the basins for three to four weeks and drain it back into the Nile River to plant crops. Thus, this system makes Egypt an agricultural country to rank among the highest agricultural producers in the world and the highest sugar cane producer in Africa (Hobbs and Saltes, 2006). This explains why sugar cane production is mainly

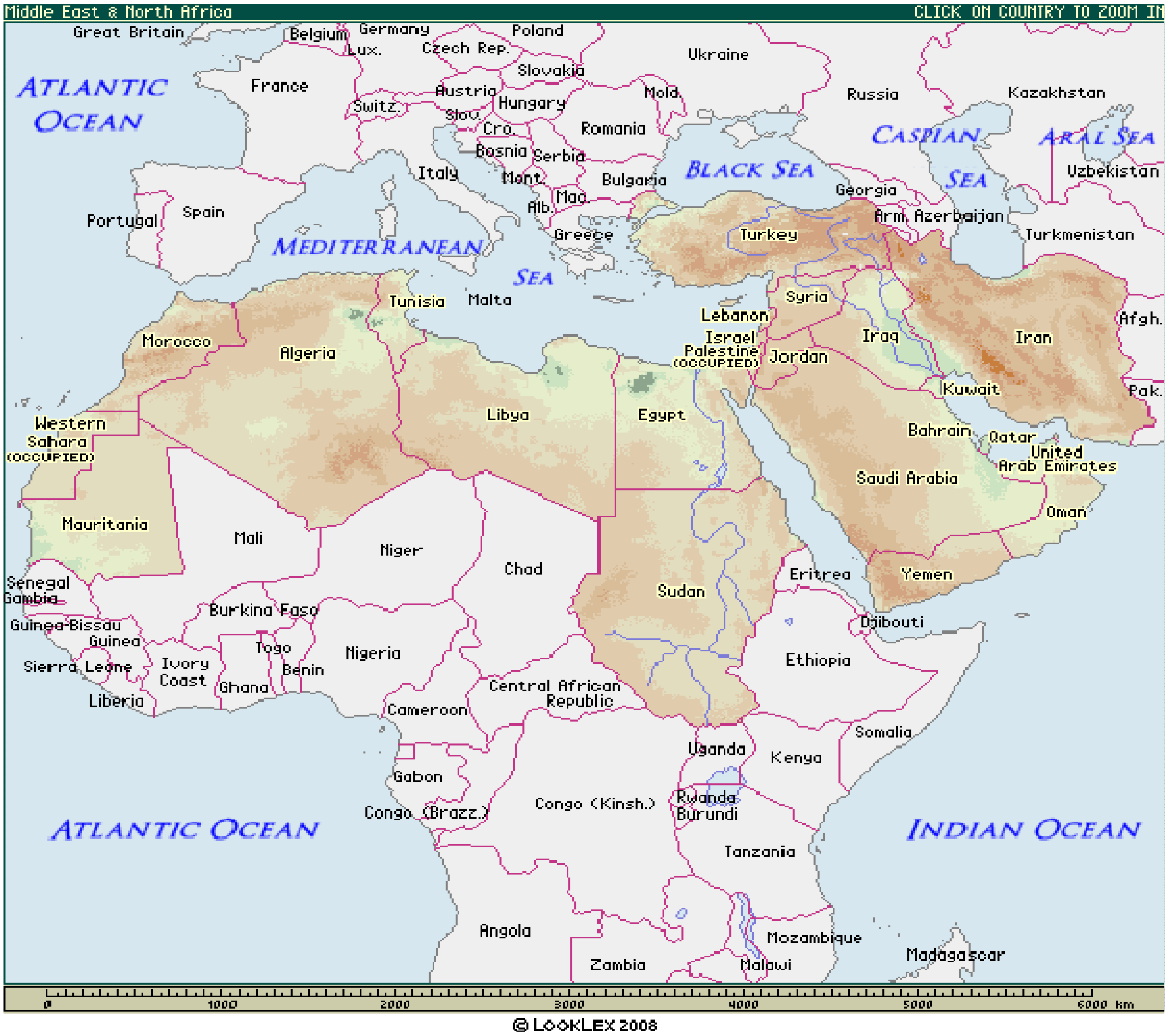

Figure 3. Map of Northern African countries and Middle East. Source: Looklex /Atlas Ltd

carried out by Sudan and Egypt and little in the other countries of North Africa.

ENERGY DEMAND IN SUB-SAHARAN AFRICA AS AN IMPETUS TO INCREASED SUGAR CANE PRODUCTION AND THE ATTENDANT PROBLEMS

Sugar cane juice and molasses can be fermented to produce ethanol. One tonne of sugar cane can produce around 100 litres of alcohol and 350 kg bagasse which on burning produces direct energy of which 60% is necessary to process alcohol. Average sugar cane yield can vary from 60 t/ha to more than 100 t/ha (6,000-10,000 litres alcohol per ha) (FARA, 2008). Africa is however, the lowest consumer of energy in the world, thus an African uses only one eleventh, one sixth, and half of the energy used by a North American, a European, and a Latin American, respectively. Even within Africa there are lots of differences between sub-regions. Over 70% of oil and 60% of natural gas consumed in Africa are used in four countries, namely Algeria, Libya, Egypt and Nigeria while South Africa uses about 93% of the coal produced on the continent (FARA, 2008).

The situation in sub-Saharan Africa where Nigeria falls, is substantially different as the region depends heavily on inefficient traditional biomass, in the form of firewood and charcoal, which accounts for over 80% primary energy demand, with the exclusion of South Africa (Karekezi and Kithyoma, 2003; Laude, 2007).

Even oil-rich sub-Saharan African countries including Nigeria, continue to rely on biomass energy to meet the bulk of their household energy requirements. This use is inefficient and in some areas puts pressure on biomass resources. There is, therefore, an urgent need for substantial increases in energy consumption in sub-

Saharan Africa to be competitive with other developing regions (Sielhorst and Veen, 2008; FARA, 2008).

In order to stem this negative tide the World Summit on Sustainable Development (WSSD) held in Johannesberg, South Africa in 2002, set up top priority targets for renewable energies and other alternative forms of energy services development. The summit agreed that every country should commit itself to meeting 10% of its national energy supply from renewable energies. The international energy community is thus showing an increased interest in biofuel as it can be considered both as a sustainable source of energy, an alternative for reducing oil-dependency, a technical option to respond to climate change and also a way to protect existing biomass or wood fuel (Zuurbier and van de Vooren, 2008; FARA, 2008; FOEE, 2008a).

It is agreed that biofuel development or first generation – crops that have traditionally been used for food such as sugar cane, cassava, sorghum, palm oil etc and even the non food biofuel crops or second generation – sweet sorghum, wood chips, switch grasses, will compete with food crops for land and water (FARA, 2008; Zuurbier and van de Vooren, 2008).

On the other hand, proponents of biofuel state that: “Biofuel could attract investment that would support agricultural improvements across the board, which would benefit food production, accelerate rural economic development, and alleviate poverty and migration to the cities” (FARA, 2008). In some places, biofuel developments have led to increased palm oil production, often at the expense of dwindling rainforests, which have been cleared to create new plantations. Thus at national level, poor consumers in urban areas and poorer farmers who are food consumers could be food insecure. While at macroeconomic level, low income countries which are net food importing will be affected by an increase in food import bill, especially where they have low foreign currency reserves (FARA. 2008).

It is essentially at the national level that corrective measures must be considered when expansive areas are opened for the production of sugar cane for sugar and ethanol production. Biofuel policy options should exclude certain staple food crops or focus on non food crops. Biofuel production should be based on higher agricultural productivity/production and also by increasing agricultural land area within environmentally sustainable limits (Ng Kee Kwong, 2007; Zuurbier and van de Vooren, 2008).

It is reported that the then EC Chairperson, Jose Manuel Barroso at the International Conference on Biofuel in Brussels, in 2007 recognized biofuel downside potential and stated “Our aim must be to develop an EU biofuel policy which meets our objectives on security of supply and climate change, while ensuring sustainable development (Jumbe, 2007; FARA; 2008). Biofuel development policies will help to minimize the “clash” between food security and energy crops production provided that they address most of socio-economic elements using positive impacts to compensate negative impacts. In pursuing the policy of biofuel production, and of course expansive sugar cane production by Nigeria and North African countries, it is necessary to ensure that such polices do not simply shift environmental problems from one sector to another or from one continent to another” (Jumbe, 2007; FARA; 2008).

BIOFUEL CROPS PRODUCTION IN NIGERIA AND NORTHERN AFRICAN COUNTRIES

Konde, (2009) asserted that one area where Africa generally, is likely to be competitive is biofuels derived from sugar cane as other than Brazil at number one, Zimbabwe (2), Malawi (3), Swaziland (4), Sudan (6), Zambia (8), and South Africa (9) and Tanzania (13) are all in the top 15 lowest cost sugar producing countries out of 77. Therefore, there is great potential for Africa to produce biofuel at production costs that could compete with petroleum at a price of $30 per barrel. Other reasons for pursuing biofuels in these countries include:
enabling more people to gain access to cleaner cooking fuels, reducing dependency on imported petroleum, acquiring technical know-how for producing biofuel, lowering the cost of transportation and creating an alternative market for surplus sugar and, for some of the countries, lowering the high transportation costs, especially in landlocked countries (Chetthamrongchai *et al*., 2001).

It is, therefore, believed that Africa wide food production is not directly at risk being pushed away by biofuel production (FARA, 2008). Although millions of Nigeria and Northern African countries’ hectares might be turned into biofuel production, this will largely take place outside existing agricultural areas.

The African share of biofuel production for EU and North American and upcoming Asian markets is expected to remain relatively modest in the coming decades by an assumed 5% in 2020 (FARA, 2008, FOEE, 2008b).

However, the huge plantation and rainfall requirement of sugar cane will make natural wetlands and rainforests with uninhabited or communal lands very attractive areas for biofuel crops production. Even with a modest share at the global level, Nigeria and Northern African countries’ biofuel production for the Northern markets and for domestic African use will demand millions of hectares to be opened for sugar cane production. The first examples in Africa the Tana wetlands in Kenya and Tano swamp forest in Cote d’Ivoire confirm this expectation (Sielhorst and Veen, 2008).

Sustainable biofuel development will require guidelines and planning by governments as such, governments in Nigeria and Northern African countries as demonstrated by Mozambique, “have to encourage peasant farmers to grow other crops which do not conflict with food production”. Greater research mobilization is needed to develop technologies that will increase productivity of sugar cane production per unit of land and laboure, to meet growing global demand for both sugar and biofuel (Jumbe, 2007).

MACRO AND MICRO-ENVIRONMENTAL IMPACTS OF SUGAR CANE PRODUCTION

Macro- Environmental impacts of sugar cane production

Production of sugar cane is associated with serious negative environmental and social impacts. The expansion of this production in particular often leads to land right conflicts, rural unemployment and biodiversity loss through the conversion of natural areas. The quest for increasing efficiency has reduced the number of workers per ton of sugar, but expansion in production has limited job losses elsewhere (Bigman, 2001). Some disturbing environmental impacts that can arise from expansive sugar cane production in Nigeria and Northern Africa are highlighted below*:*

Further deforestation by displaced cattle farmers

Sugar cane is often being produced on land that was previously owned by cattle farmers. These cattle farmers may then convert new nature into grazing areas. That way, sugar cane production will indirectly lead to deforestation and the conversion of natural habitats (FARA, 2008).

Climate change

Burning fields and bagasse contribute to the emission of carbon dioxide (de Carvalho, 2005). Decomposition of bagasse – an alternative to burning – leads to the emission of methane, which is an even more powerful greenhouse gas (Wang 1999).

Droughts

Sugar cane production can lead to droughts for two main reasons. First, deforestation may result in changes in precipitation patterns. Second, the irrigation needed for its production requires large amounts of water (Sielhorst and Veen, 2008).

Micro-Environmental impacts of sugar cane production

Land conflicts

It is generally known that in increasing market standards of refined sugar processing, the ability of smallholders to compete in sugar processing declined and more and more large sugar cane monocultures appeared. Regularly, movements of landless people occupy land, resulting in violent conflicts with the legal owner, who is often supported by the police. The rate of conflicts is said to have gone up as the result of the increased sugar cane production (FARA, 2008). Moreover, the continuous sugar cane planting for many years in the same land will result to less cane production.

Human health risks

Using large amounts of agrochemicals leads to run-offs and spillage. Local communities face health problems as they drink contaminated water or live too close to fields that are being sprayed (Pimental and Lehman, 1993, Sielhorst and Veen, 2008, FOEE, 2008b).The areas at risk, with low population densities and enough fresh water are also the most important 'hotspots' for African biodiversity. In addition to the loss of natural areas, biofuel production has negative local impacts on people downstream of the plantations. Biofuel like sugar cane consume large quantities of water, cause erosion and demand fertilizer and pesticides. This will affect many people as many directly depend on water quantity and quality of nearby wetlands such as rivers and marshes. Locally, food production might be at threat by the establishment of sugar cane biofuel plantations (Sielhorst and Veen, 2008).

Child and slave labour:

In Nigeria and some Northern African countries, the exact or overall numbers of child and slave labour are unknown, but it is clear that child labour is being used in sugar cane production elsewhere especially in Brazil the leading sugar cane grower in the world (Sielhorst and Veen, 2008).

Erosion and soil degradation

Expansive sugar cane production is a monoculture, which is not part of a rotation scheme, depletes the soil. Therefore, more fertilizers will be needed over time and the quality of the soil will diminish. Thus, laying the lands bare to plant them with cane has a tremendous impact on the soil. The protective cover is being stripped away, the soils dry out and the essential microorganism diversity and mass is affected. Exposed topsoil is easily washed away, taking away essential nutrients (Thorburn *et al.*, 2007). This leads to a loss of soil health and fertility. This, in turn, leads to an increased need for fertilizers and may again lead to soil acidification and further deterioration of microbiological soil life (Quirk *et al.*, 2007).

Soil depletion is also caused by the fact that all cane is removed from the land and none of the nutrients are returned to it (Noronha *et al.,* 2006; Sielhorst and Veen, 2008).

A solution to this problem and for sustainable sugar cane production, however, lies in soil organic matter conservation which is most often gauged in the medium or long term through the use of animal and plant residues to supply a portion of the nutritional requirements of plants, and to address soil productivity in order to improve the consistency of continuous and expansive production as for sugar cane (Thorburn *et al*., (2007). Such a system is usually attained through sustainable and efficient ways to increase the efficiency of chemical fertilizers and leads to improvement in soil health (Seeruttun *et al*., 2007).

Air pollution

As observed by Sielhorst and Veen, (2008), sugar cane is burned before manual harvesting in order to remove sharp leaves and snakes, however, this practice leads to serious air pollution and has proven hazardous to human health (Wang, 1999, de Carvalho, 2005). Otherwise, in Egypt, sugarcane is not burned at harvesting and cleaned manually with high costs, mainly air pollution comes from factories which have no control for that issue.

Water pollution

Sugar cane production requires high nutrient inputs, which may enter the aquatic system due to leakage and run-off, leading to eutrophication. Aerial spraying of insecticides and herbicides also leads to water pollution, as do wastewater from the mills and cleaning the equipment, when major quantities of plant and sludge enter the aquatic system and by decomposing absorb all available oxygen (Sielhorst and Veen, 2008). It is required that new resistant varieties should be developed to decrease the use of pesticides.

High water use

As producing sugar cane needs a large amount of water (growing and processing) one kilo of sugar requires 1500 to 3000 litres of water, water resources will overexploit. There is an excessive use of groundwater and riverbeds are being exposed. Poor drainage and inefficient use of water leads to water logging and salinization of soils (Sielhorst and Veen, 2008, FARA, 2008). The efficiency of water use should take place during the development of such new sugar cane varieties.

Use of Genetically modified sugar cane GMOs

Genetically modified sugar cane has not been commercialized yet, but research and field testing of several varieties are taking place and some are very close to commercialization in several other cane producing countries of the world including Egypt and Sudan (de Carvalho, 2005; FOEI, 2008) and no such hopes are for Nigeria at present.

Low wages

Sielhorst and Veen, (2008), further observed that wages in sugar cane production are low, and as sugar prices have fallen, wages start going down in order for the land- or factory owners to maintain their standard of living. In some cases, workers do not even earn enough to cover the calories they burn on the job. Such negative experiences abound to occur in Nigeria and North African countries' expected increased sugar cane production as is already the case with Brazil (Aparecida de Moraes Silva, 2006).

Bad working condition

Working conditions in sugar cane production are amongst the most hazardous of any agricultural industry in the world including Nigeria and Northern African countries (Sielhorst and Veen, 2008).In contrast to the industrialized world which is worried by the long-term global environmental impact of current patterns of energy production and use, Nigeria and Northern African countries are much more preoccupied with the immediate problems of meeting the long-standing and pressing demands for a minimum level of energy for the majority of the poor, many of who have no electricity and continue to rely on inefficient and environmentally hazardous unprocessed biomass fuel (FARA, 2008; Sielhorst and Veen, 2008). According to Zuurbier and van de Vooren (2008), sugar cane based ethanol can instead, contribute to the achievement of several MDGs through a varied range of environmental, social and economic advantages over fossil fuels. These include enhanced energy security both at national and local level; improved trade balance by reducing oil imports; improved social wellbeing through better energy services especially among the poorest; promotion of rural development and better livelihoods; product diversification leaving countries better off to deal with market fluctuations; the creation of new exports opportunities; the potential to help in tackling climate change through reduced emissions of greenhouse gases as well as other air emissions; and opportunities for investment attraction through the carbon finance markets (Wang, 1999). Thus, highest impact on poverty reduction is likely to occur where sugar cane ethanol production focuses on local consumption, involving the participation and ownership of smallholding farmers and where processing facilities are near to the cultivation fields.

Some other major problems of sugar cane production in Nigeria and Northern African countries

The following are the most critical identified problems that hinder the growth and expansion of the sugar cane

Table 1. Area under cultivation and the quantity of sugar cane produced in Nigeria.

	Area ('000') ha			Production ('000') tons		
	Commercial	**Chewing**	**Total**	**Commercial**	**Chewing**	**Total**
2000	15.00	24.00	39.00	52.00	793.00	845.00
2001	13.00	32.00	45.00	35.00	883.00	918.00
2002	8.00	40.00	48.00	15.00	975.00	990.00
2003	0.00	46.00	46.00	0.00	982.00	982.00
2004	0.00	47.00	47.00	0.00	712.00	712.00
2005	0.00	47.00	47.00	0.00	712.00	712.00
2006	0.10	47.00	47.10	0.54	949.00	949.54
2007	0.10	47.00	47.10	0.59	1411.00	1411.59
2008	0.11	51.70	51.81	0.59	1552.10	1552.75
2009	0.12	56.87	56.99	0.59	1707.31	1708.02

Sources: Various Central Bank of Nigeria (CBN) Annual Reports, Factory data of Dangote, Savannah Sugar Company, 2006/7.

industry in Nigeria and Northern African countries:

Low sugar cane production productivity in Nigeria and Northern African countries

Sugar cane production had fluctuated in Nigeria particularly, thus attaining near zero value in the early 21st century as the result of the total collapse of the two sugar factories. The productivity of the cane equally dove tailed to zero during the same period. Generally, considering the total sugar cane produced by all African countries, it is right to deduce that northern African countries did not fare better than Nigeria during the same period as shown in (Tables 1 and 2) respectively.

Some of the factors that contribute to low farm productivity of sugar cane plantations in the reviewed areas:

Use of exotic varieties

Sugar cane planters in Nigeria and Northern African countries are not particular in choosing the right cane variety to use. Majority of cane growers, about 65% still use local land races of sugar cane the chewing type while about 13% practiced the use of mix varieties. In Egypt, there is one variety which has been under commercial cultivation for nearly 40 years and other new cultivars are under the experimental trials.

Inability of some farmers to apply the necessary farm inputs

Majority of the planters about 90% are considered small holder farmers who usually crop below 5 hectares, with income below the poverty level hence cannot afford to sustain the input requirement in sugar cane farming without outside financial support. As they rely solely on the releases of production loan from cooperatives at the right time and rate of application of fertilizers and other farm inputs is hardly observed. Fertilizer application is usually late and oftentimes, only one application is affected (Thorburn *et al*., 2007). In Egypt, however, large doses of fertilizer, especially the nitrogen types, are applied several times throughout the growing season.

Solely dependent on rain water for irrigation

Almost all sugar cane plantations are dependent on rainfall for its water requirement; hence time of application of fertilizer is affected.

High cost of starting capital and production inputs

Sugar cane production requires quite big amount as starting capital for a hectare plantation. Of these, 18% accounts for planting materials and 14% for fertilizer. High interest rates from commercial banks prevent investors from seeking loans to establish sugar cane plantations and sugar plants which are both capital intensive (Dangote, 2003).

Lack of technology/knowledge and facilities on proper land preparation technique and methods

Majority of sugar cane grower's especially small holder farmers still use hoes and machetes in land preparation. Very few farmers, who own big planters with machineries, employ mechanical land preparation. Available units are not sufficient to serve small farmers in the neighbouring area and are not big enough to accommodate the sub-soiler (Sharpe, 1998).

Production credit is not available to producers especially to small holder farmers

Production loan for sugar cane production is normally

Table 2. Global significance of sugar cane production in 2007.

	Sugar cane			Cultivated land million ha	Sugar cane % of total cultivated percent	Sugar cane ethanol land million ha	Ethanol % of sugar cane Percent
	Harvested million ha	Production million tons	Yield tons/ha				
North America	0.4	28	77.6	229.3	0.2	0	0
Europe & Russia	<0.1	<1	61.4	296.4	0.0	0	0
Oceania & Polynesia	0.5	40	79.9	54.8	0.9	0	0
Asia	9.6	639	66.4	577.1	1.7	<0.1	<1
Africa	1.6	92	56.8	239.3	0.7	<0.1	<1
Centr. Am. & Carb.	1.8	114	63.4	42.9	4.2	<0.1	1
South America	8.0	611	76.5	121.9	6.6	3.6	45
Developed	0.9	67	78.9	580.4	0.1	0	0
Developing	21.0	1457	69.2	981.3	2.1	3.8	17.8
World	21.9	1524	69.6	1561.7	1.4	3.8	17.1
Brazil	6.7	514	76.6	66.6	10.1	3.5	50
India	4.8	323	72.6	169.7	2.8	<0.1	n.a.
China	1.4	106	86.2	140.0	1.0	<0.2	n.a.
Thailand	1.0	64	63.7	17.8	5.7	<0.1	3
Pakistan	1.0	55	53.2	22.1	4.7	0	n.a.

Source: FAOSTAT, 2008, Licht, 2007, 2008; calculation by the authors,[1]Estimates of cultivated land refer to year 2005.

served to farmers by lending institutions like commercial banks in the respective countries of Nigeria and the Northern African countries as well as the African Development Bank (ADB). Poor condition and lack of access roads contribute to delays in cane produced's delivery and hence lower recovery (Chetthamrongchai *et al*., 2001).
Technology transfer and proper technology application are also inadequate in Nigeria and Northern African countries. In Egypt, there are special railways and tractors which are used to transfer the millable cane from fields to factories.

Lack of legislative protection for the local sugar industry

There has been no legislative law protecting the local sugar industry in Nigeria since its inception in 1961 until 2003. There is now a 10% levy on sugar imports and 40% tariff to meet International Sugar Organization (ISO) standard of other sugar producing countries (Anon, 2003). Similarly, Northern African countries, with the exception of Egypt, do not have protection laws for sugar cane growers. In Egypt, for example, sugar cane is among the range of GM crops that have been approved for trials and the nature of genetic engineering research conducted by the country's Institutes of Scientific Research demonstrate solid evidence on the development of this front (Paarlberg, 2006).

Lack infrastructures in the rural areas

Irrigation facilities, health centres, schools and recreational facilities are inadequate in areas where the bulk of sugar cane and cane growers abound.

Lack of easy access to land

Of recent, prospective investors have had enough trouble trying to acquire land for the establishment of sugar plants in Nigeria for instance (Dangote, 2003).

Involvement of government in sugar production with no market outlay

Since inception, the Government of Nigeria and Northern African countries has had direct involvement in the establishment and funding of the existing sugar companies without adequate checks and balances on the management and profit outlay of the companies. The Governments of these nations did not provide the enabling environment for the sale of the high cost sugar produced by the companies against cheap imported sugar dumped on them by Brazil and EU countries, aided by unpatriotic businessmen who favoured quick money making from the imports rather than investing in the local production of sugar. Thus the least tariff of 15% was charged on imported sugar with a levy of less than 5%, which fell below the regulations and guidelines of the ISO General Agreement on Trade and Tariff (GATT) and World Trade Organization (WTO) (Anon, 2003; Wada *et al.,* 2006).

Constant hiking of petroleum products

Both the large and medium scale sugar plants require fuel to operate. The high cost of Low Pour Fuel Oil (LPFO) and other fuels make production cost of any local sugar quite high (Dangote, 2003). Thus, investors in the sugar cane and sugar industry are quite apprehensive of these costs.

Lack of private sector investment

As stated earlier, the Nigeria sugar industry had been solely owned by Government till recently. Elsewhere stakeholders in the sugar industry participate and fund sugar production as well as R & D on sugar (Atiku, 2003).

Non funding of sugar cane research and development

In view of the above and because of the ever increasing demands on the resources of government, funding cannot but be inadequate. This is at variance with what obtains in other sugar producing countries of the world. In these countries, the responsibility for funding research in the sugar sector is shared between government, the sugar companies and the cane growers (Wada *et al*, 2006).

Lack of central coordination of the direction of research in the sector

In addition to inadequate funding, there is a lack of central coordination of the direction of research on sugar cane in Nigeria particularly, while in Egypt and Sudan there are coordinated direction for R & D in sugar cane to influence grower's productivity. Such coordination will set research priorities based on the appraisal of all the stakeholders and determine the activities that should have funding support from a central body. However, bodies like Arab Maghareb Union (AMU), Association for strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Community of Sahel – Saharan States (CEN-SAD), COMESA , Common Market for Eastern and Southern Africa, (FARA), International Council for Science (ISCU) and Southern African Development Community – Food Agriculture and Natural Resources (SADC–FANR), have been formed to address this limitation in coordinated research in Africa generally (AU/EXP/ STEERING /ST/6 (III), 2007; FARA, 2008). In addition, in Egypt there is a great cooperation among the Sugar Technology Research Institute (STRI) in Assiut University, Egyptian Sugar and Integrated Industries Companies and Egyptian Council of Sugar Crops which direct and achieve the scientific researches to solve the problems as well as arrange the information for sugar industries.

Lack of defined fertilization rates for optimum sugar cane and sugar yields

Mohmoud *et al*. (2008), reported that applying 260 kg N, 30 kg P_2O_5 and 72 kg K_2)/ha to sugar cane variety Phe 8113 achieved the highest value of millable cane yield/ha and recoverable sugar yield and consequently increased net income value of the growers in Egypt. Ahmed *et al.* (2008) also reported that excessive use of nitrogen fertilizer application can affect stalk and sugar yields and sugar recovery. They reported that using 220Nkg/ha was optimum to attain the highest value of sucrose %, sugar recovery and sugar yield. These are isolated studies that could be harmonized through international or regional research bodies to benefit Nigeria and Northern African countries to improve on sugar cane productivity through efficient and appropriate fertilizer application on the crop. The high cost of fertilizer is a big problem of recent in Egypt for sugar cane and other crops. Also, the rate of fertilizer/ha is very high which increase the costs for high productivity.

Tang *et al*. (2008) in their study on influence of fertilized mud, vinnasse and sugar cane residues in soil microbe population in sugar cane field reported that soil bacteria actmycetes and fungi were increased by application of the organic material. Other workers found that filter mud was a very beneficial organic nutrient source for the production of sugar cane in Iran and South Africa (Abdullahi *et al*., 2007; Van Antwerpen *et al*., 2007). Thus inappropriate application will lead to soil microbe increase with interference on sugar cane growth, while appropriate rate will serve to understand the interrelationship of soil microenvironments nutrients availability which helped in improving fertilizer efficiency in China (Tang *et al*., 2008). However such studies are not common in Nigeria and Northern African countries and should be started to improve soil microbe nutrient balance and sustainability for increased sugar cane production productivity.

Lack of proper fertilizer and irrigation management as well as nitrogen fixation studies in sugar cane production

Studies involving vinasse as a potassium source

Table 3. NEPAD Office of Science and Technology (OST) networks of centres of excellence in biosciences.

Networks	Nodal Point	Hub National	Centre Focus	Area of Work
NABNet (North African Biosciences Network)	Egypt	Research Centre (NRC)	Bio -Pharmaceuticals	North Africa: to lead the continent in research into bio-pharmaceuticals, drug manufacturing and test kits.
WABNet (West African Biosciences Network)	Senegal	Senegalese Institute of Agricultural Research (ISRA)	Crop Biotech	West Africa: to carry out research using biotechnology tools to develop cash crops, cereals, grain legumes, fruits. vegetables and root/tuber crops.
SANBio (Southern African Network for Biosciences	South Africa	CSIR, Bioscience Unit	Health Biotech	Southern Africa: to deliver benefits from health biotechnology by researching into the causes and prevention methods of a range of diseases, in particular, TB, malaria and HIV/AIDS.
Bec A Net (Biosciences East and Central African)	Kenya	International Livestock Research Institute (ILRI)	Animal Biotech	East Africa: to focus on research into livestock pests and diseases in order to improve animal health and husbandry. Central Africa: to build and strengthen indigenous capacity by identifying, conserving and sustainably using natural resources and also researching into the impact on biodiversity of events such as climate change and natural disasters

Adapted from Makinde *et al*., 2009.

associated or not with the trash from mechanical green cane harvesting and nitrogen levels on ratoon sugar cane sustainability in Brazil showed that trash layer reduced cane yields and increased the levels of P_2O_5 in the juice while vinasse application resulted in higher productivity as well as higher levels of K_2O in the juice (Casagrande *et al*., 2007). Vinasse and filter mud use on sugar cane have increased productivity but these are not used in Nigeria and many other Northern African countries (Tang *et al*., 2008). The replacement of nitrogen from crop off-take and environmental losses has also been suggested as a sustainable system of nitrogen management for sugar cane production. Thus, in conjunction with field trials to test the “N replacement” concept in the range of environments spanned by the Australian sugar cane industry as well as increased efforts in monitoring N stress in cane using Near Infra Red Reflectance instrument (NIR) located at sugar mills were made by Thorburn *et al*. (2007) with encouraging results, which indicated little average difference in yield between replacement and conventional N treatments. Results also showed that using the good NIR calibrations obtained for predicting sugar cane N concentration compared well with field measurements which can be used where there are needs to improve cane profitability and reduce environmental impacts of expansive sugar cane production expected to take place in Nigeria and Northern African countries (Smeets *et al*., 2005, 2008).

Sugar cane is a high biomass crop requiring lots of water but water for its irrigation is becoming increasingly limited and, therefore, must be used as efficiently as possible as deficit irrigation may lower yields, but may increase the amount of cane produced per unit of water used by the crop (Wiedenfeld, 2007). Thus, Chattha *et al.*

(2008), in Pakistan, reported that trench planting at 120cm apart was superior to furrow planting for irrigation water management. Also, the irrigation to all trenches of 120cm apart produced the maximum cane yield but alternate strip irrigated method with 300cm water was a better option with maximum water use efficiency. The workers further observed that in the months of severe water shortage, plastic mulch withstood drought properly with minimum reduction in cane yield. Trench farming which ensures efficient irrigation water use for increased sugar cane productivity is not common with Nigeria and Northern African countries sugar cane production systems.

Again, some sugar cane varieties are known to be capable of fixing atmospheric nitrogen in association with the bacterium *Glucoacetobacter diazotrophicus* (Tomkins *et al*., 1999). Unlike legumes and other nitrogen fixing plants which form root nodules in the soil in association with bacteria, *G. diazotrophicus* lives within the intercellular spaces of the sugar cane's stem (Boddey *et al*., 1991, Yamada *et al*., 1998).

Limited biotechnological advancement in sugar cane research

In Louisiana, USA, Pan *et al*. (2008), with the use of SSR stored genotypes of sugar cane in a local data base of the USDA – ARS – SRL for use to verify clone identity, access the fidelity of crosses and determine the paternity of poly crosses. The HT – SSR genotyping procedure could have general ability to other sugar cane breeding programmes in Nigeria and North African countries (Richard, 2009). However, at present biotechnological studies for improved sugar cane productivity are lacking particularly in Nigeria.

Generally, African countries often lack the market structures, appropriate and supportive regulation and good partnership arrangements and as such support for biotechnology products in agriculture remains low. This affects research interests in plants and animals even for non-food purposes, and hinders the building of the necessary capacity that would have benefited other sectors (Konde, 2009).

Makinde *et al*. (2009), reported that in order to address the issue of inadequate resources to develop and safely apply biotechnology (human, infrastructure, and funding) the African Union (AU) through the New Partnership for African Development (NEPAD) Office of Science and Technology (OST) established the African Biosciences Initiative (ABI) in 2005. This led to the creation of networks of centres of excellence in strategically placed hubs around the continent, viz, BecANet in Kenya, SANBio in South Africa, WABNet in Senegal, and NABNet in Egypt; with these hubs are a number of nodes. Each of the five AU regions has the following biotechnology missions to carry out as detailed in (Table 3).

Thus, in some Northern African countries, biotechnological advancements are being made to increase and improve sugar cane production. Thus, molecular markers and molecular biology techniques have been used in identifying the genetic diversity among sugar cane varieties as well as in accelerated selection programmes for smut resistance in a cost-effective way in Egypt (El-Seehy *et al*., 2008; Abd El-Tawab *et al*., 2008; Taghian and El-Aref, 1997; Abo-Elwafa, 1999a; Abo-Elwafa 1999b; Abo-Elwafa and Ismail, 1999; Abo-Elwafa and Ahmed, 2001a; Abo-Elwafa and Ahmed, 2001b; Abo-Elwafa and Abo-Salama, 2003; Abo-Elwafa, 2004; Abo-Elwafa, 2007; Abo-Elwafa 2011; Fawaz *et al*., 2013; Fawaz, 2014; Abo-Elwafa *et al.,* 2015). Such studies have not been carried out in Nigeria where whip smut is the major sugar cane disease limiting yield (Wada, 1997, 2003). Similarly, Saadalla *et al*. (2008) using *Agrobacteria* mediated transformation developed cane varieties resistant to stemborers in Egypt. Thus, this present insect pest problem of Nigeria sugar cane production can be solved through similar biomarker studies when such facilities become available to NCRI the national institute assigned with the genetic improvement mandate on sugar cane in the country.

Lack of biological control studies for pests and diseases

Abou-Salama, (2004) stated that Egyptian sugar cane industry was bewildered with heavy infestation by soft scale insect *Pulvinaria ternivalucta* (Newstead) as the result of pesticide usage which led to the reduction in its natural enemies in the field. At present there are no studies on biological control methods for pests and diseases in Nigeria and many other Northern African countries to mitigate similar experiences like those in Egypt.

The use of biological control for important pests of sugar cane in other sugar cane growing countries of the world especially Brazil for the sugar cane borer (*Diatraea saccharalis*), sugar cane beetles (*Migdolus fryanus*) which is considered the most important pest and the *cigarrinha*, *Mahanarva frimbriolata* has not started in Nigeria for the control of stem borers, especially the *Eldana spp*, termites, beetles and leaf cutting ants. It is therefore, difficult to reduce pesticides use through selective application as is the case in Brazil, India, USA and China where biological control r are well developed. (Zuurbier and van de Vooren, 2008).

With borers becoming resistant to costly insecticides, scientists in Nigeria and Northern African countries should resort to utilizing the biological control agent, *Trichogramma chilonis*, a parasite that feeds on the sugar cane borer's eggs as was the case in the Philippine sugar cane industry (The Philippine Star, 2005). However constructed laboratories to mass-produce *Trichogramma*, are lacking in the reviewed countries.

Nematodes and white grubs are pests that feed on sugar cane roots, causing growth stunting in cane plants. Nematodes are worm-like organisms that are hardly seen by the naked eye, while white grubs are beetles in their larval stage. *Heterodera zeae* is very widespread and affects sugar cane from North Africa and India (Dick, 1966). Scientists at NCRI should study the pests' life cycle and search for ways to develop biological control agents that will be effective in eradicating nematodes and white grubs as is the practice in other sugar cane industries of the world (The Philippine Star, 2005). Thus, helping planters combat sugar cane diseases and pests should be a continuing exercise for Nigerian and other African countries' pathologists and entomologists**.**

Problems of crop vulnerability or biotic stresses

Generally, outbreaks of sugar cane diseases and pests wreak havoc on sugar production Numerous pathogens infect sugar cane, such as sugar cane grassy shoot disease caused by *Phytoplasma* (Tran-Nguyen *et al*., 2000), Whiptail disease or sugar cane whip smut caused by *Sporisorium scitamineum*, Pokkah boeng caused by *Fusarium moniliforme*, and Red rot disease caused by *Colletotrichum falcatum*. Virus diseases affecting sugar cane include sugar cane mosaic virus, maize streak virus, and sugar cane yellow leaf virus (Sharpe, 1998). Problems of crop vulnerability are best solved with the use of resistant varieties (Simmonds, 1991). The experience of Barbados can best be copied in this field by the relevant scientists if the prevailing biotic stresses reducing sugar cane yield in Nigeria and other North African countries are to be effectively managed. Barbados has its own cane breeding station, and it has a wealth of cultivars to choose from. The Barbados scientists decided to test as many of them as possible in South America, so that they would know in advance which cultivars were susceptible. The idea was to remove any susceptible cultivars from cultivation, as part of the routine replanting process, and to do this before the diseases appeared in the island. (Robinson,1987; Beek, 1988).

Thus, the best selections of one screening generation became new cultivars. They also became the parents of the next screening generation, with another three million seedlings. This approach, of course, is recurrent mass selection, and it is the basic method of population breeding. It emphasizes the transgressive segregation of continuously variable characters that are polygenically inherited, such as sucrose content, total yield of cane at the time of harvest, horizontal resistance to pests and diseases, and so on (Van der Plank, 1968; Simmonds, 1991; El-Geddawy *et al*., 2008). Pathologists and plant breeders in Nigeria and Northern African countries should start breeding for horizontal resistance which must be completed before the inbreeding is started, and the selection pressures for resistance must continue during the formation of the inbred lines in order to achieve desired results of resistant sugar cane varieties to notable biotic stresses (Robinson, 1987).

In Nigeria and Northern African countries as well as elsewhere in the last 14 years, reduction in tonnage due to mosaic disease averaged 23 percent. In the Philippines, for example, yellow spot disease's first outbreak in variety Negros resulted in a yield loss of 16 percent. Thus, catastrophes like these prompted the Philippine Sugar Research Institute Foundation Inc. to create efficient management programmes to address the problems (The Philippine Star, 2005). Few or no such research foundations exist in Nigeria and Northern African countries to evolve strategies for the management of biotic stresses occasioned by pests and diseases. Whip smut is the most prevalent sugar cane disease in Nigeria, while downy mildew is a disease problem in Northern African countries, particularly Egypt (Wada, 1997, 2003; Wolters, 2010).

Rodents especially rats are also a problem of sugar cane production in Nigeria and Northern African countries. Rat population is hard to contain as a female rat can produce over 2000 off springs in a year (Wolters, 2010). Sugar cane borers are most destructive during the dry season with infestation ranging from 50 to 70 percent. Plants attacked by the pest do not mature, resulting in low sucrose content and a low yield. There are some dangerous insects attacking the sugar cane plants which results to loss in yield in Egypt such as *Sesamia cretica, Chilo agamemnon, Pulvinaria tenuivalvata and Gryllotalpa gryllotalpa*. These insects need directed research aimed at breeding new cane varieties for resistance against them.

Problems of weed infestation and lack of efficient management strategies

The management of weeds in other cane producing countries of the world like Brazil, India, China, USA, South Africa and the Caribbean encompasses specific methods of mechanical, cultural, chemical and biological, thus making up an extremely dynamic process that is often reviewed. For example, in Brazil, sugar cane uses more herbicides than coffee and maize crops, less herbicide than citrus and the same amount as soyabean (Robinson, 1987). Most cane growers in Nigeria, especially chewing sugar cane farmers hardly employ the use of chemical weed control but depend largely on the drudgery of cultural weed control by hoe weeding of up to 5 to 7 times.

In other sugar cane producing countries especially in Brazil, the sugar cane growers association in conjunction with the mills, have developed set goals aimed at improving sugar cane productivity related to the use of agrochemicals, soil management and water uses (Zuurbier and van de Vooren, 2008). Regrettably, in Nigeria, there is not even any single recognized sugar cane growers association formed to regulate or influence decisions on the effective use of agrochemicals, soil management and water use. There are new dangerous weeds found recently in the fields of sugar cane which cause losses in productivity in Egypt such as *Convolvulus arvensis*, as well as *Cynodon dactylon* an older weed.

Lack of efficient management strategies for biotic stresses

Strategies for disease control which involve the development of disease resistant varieties within large genetic improvement programmes in other cane producing counties like Brazil are lacking in Nigeria and in most other Northern African countries (Zuurbier and van de Vooren 2008). The technique of sugar cane as semi permanent culture of annual cycle and vegetative propagation which forms a crop planted with a certain variety that is reformed only after 4 to 5 years of commercial use in Brazil (, for example does not exist in, Nigeria and other Northern African countries as a disease management technique. These characteristics determine that the only economically feasible disease control option is to use varieties genetically resistant to the main crop diseases like *Sporisorium scitamineum, Colletotrichum falcatum, Nyphyisiophaneria sp* and *Fulsarium morniforme* (Robinson, 1987).

Lack of appropriate and well equipped laboratories

As reported by Robinson, (1987) the way out to the problem of continued yield and quality decline of Nigerian and other Northern African countries' sugar cane due to the effects of biotic stresses is to start regional horizontal breeding programmes. This is because sugar cane is derived from a continuous pathosystem, all of its resistance to pests and diseases is horizontal resistance. The vertical resistances, that have caused so much trouble in crops derived from discontinuous wild pathosystems, such as potatoes, tomatoes, wheat, rice, peas, and beans, do not occur in sugar cane (Robinson, 1987).

A major problem limiting the adoption of breeding programmes on horizontal resistance in Nigeria and Northern African countries is unequipped and under staffed laboratories. Elsewhere, as a result of some decades of this kind of breeding, Hawaii, for example, now has a wealth of outstanding cane cultivars which, however, are not often useful in other parts of the world because of differing environments, and differing patterns of pests and diseases (Simmonds, 1991). It is thus, safe to assume that all resistance to sugarcane pests and diseases is horizontal resistance, so bred resistant sugar cane varieties should not break down to biotic stresses against which they were bred. However, due to faulty or inadequate testing, a new cane cultivar which might be very susceptible to some diseases might not have been tested carefully enough before being released to farmers (Simmonds, 1991).

Problems due to different harvesting systems

There are varied production and harvesting systems for sugar cane in Nigeria and other North African countries as well as differing varieties of sugar cane in these areas. These variations ordinarily create problems of the best harvesting system that should be adopted in harvesting the crop. The ideal in cane harvesting would be to crush all cane within a specified period of, say, two months, when nearly all the crops would be at their peak of maturity (Yadav, 2007; Viator *et al*., 2009).

This is obviously impracticable for such reasons as availability of seasonal labour, transport (Chetthamrongchai *et al*., 2001) and the milling/distilling capacities of factories. An effort should, however, be made to harvest and mill an average crop in as from twenty to twenty five weeks. Also harvesting the oldest ratoons early is not a great concern for growers since this cane will be destroyed and replanted. Often, though, the oldest ratoons are low yielding so they are harvested within a short time period leading to an early harvest of younger ratoons within the first month of the crushing season (Viator *et al*., 2009). This, therefore, results in cane being immature at the start of the season and over matured at the finish of crushing (Wada, 2008). The solution to this problem lies in synchronizing the planting and the types of varieties to be planted**.** However, such synchronized plantings and uniformly matured cane varieties are scarce in Nigeria and Northern African countries as of date.

Problems due to different harvesting methods

Sugar cane is harvested either manually or by mechanized cutting. Mechanized cutting is more efficient but is of limited practice at present in Nigeria and most Northern African countries. Mechanized harvesting equipment is capable of either cutting the intact cane stalk or chopping the cane into bits. Separation of extraneous matter is very critical during harvest, since certain types of extraneous matter notably cane tops increase the non-sugar content and interfere with crystallization during processing (Yadav, 2007). In this regard, manual harvesting should be preferred, but what of its high wage bill?

Problems of manual harvesting

Manual harvesting simply implies the cutting of cane using cutlasses or machetes close to the ground level to ensure good stubble growth. Hand harvesting accounts for more than half of production, and is dominant in the developing world (Yadav, 2007). In hand harvesting the field is first set on fire, but this practice is not found in Egypt. Owing to the many hectares planted to sugar cane by sugar estates, large numbers of men are needed to harvest matured cane within a short period of time. The wages for manual harvesting are always high and add to total production cost of the processed sugar from such harvests. Herein lies one of the greatest problems for the sugar cane industry in Nigeria and other Northern African countries as full mechanized harvesting is yet to be adopted by them. Thus, their produced sugar is always costlier than the imported one**.**

Problems with mechanical harvesting

Mechanized harvesting is of limited use in sugar cane industries in the Nigerian and Northern African countries as the general conditions under which mechanized harvests are conducted vary widely. Sugar cane fields can be located on flat and rolling land with narrow beds and field drains at close intervals, hillsides with cane rows following the contours, banks with intervening deep furrows; and other field systems depending upon the soil, the terrain and the rainfall. These terrains create problems in using the usual mechanical harvesters such as the combine or chopper (Yadav, 2007).

In addition, varieties of cane differ in their habit of growth, and still other factors add to the complexity of those which must be satisfactorily met if mechanical harvesting is to succeed (Yadav, 2007). In this regard erect canes of regular growth are more easily dealt with, and free trashing of the stem is a great advantage. Some varieties, while giving good yields of rich cane have a spreading habit, and still others tend to lodge and offer a tangled mass to the human cutter and the machine. Neglect in early growth stages of the cane results in weed infestation which offers still another objectionable obstruction.

It is thus realizable that cane harvesting machines have to be designed to cope with the peculiar groups of conditions met within the areas in which they are to operate (Yadav, 2007).

In consequence, the sugar cane in Nigeria for example, at present is generally manually harvested using cane cutters grouped in gangs as is the case at Savannah Sugar Company (Dangote Group) or at Bacita (Josepdam) Sugar Company.

Similar difficulties also abound in other Northern African countries in the use of mechanical harvesting of sugar cane. Where mechanical harvesting is practiced, the advantages include enhanced productivity, timeliness of operation, work quality, and utilization of inputs and resources such as seed, fertilizer and chemicals, along with reductions in total cultivation costs and human drudgery (Yadav, 2007).

Lack of use of sugar cane bye-products and the quest for biofuel development

African biofuel production for the Northern markets and for domestic African use demands millions of hectares of cane in Africa, because sugar cane juice is very perishable and need processing within one or two days.This demands huge plantations of thousands of hectares in the proximity of a mill. In 2005, the Nigerian Government signed the Tokyo Agreement to engage in the blending of its putrefied motor spirit (PMS) petrol with 10% ethanol by the end of October of the same year hoping to follow the experience of Brazil.

However, to date there has been no tangible achievements on the E10 Ethanol for fuel programme by Nigeria, thus slowing the pace of massive sugar cane production.

Ethanol is generally available as a bye-product of sugar production. It can be used as a biofuel alternative to petrol, and is widely used in cars in Brazil (Zuuobier and Van de Vooren 2008).

Consequently, the Nigerian National Petroleum Corporation (NNPC) was charged with this responsibility and the Renewable Energy Division of NNPC was created to oversee this green fuel development. Accordingly the Sugar cane Research Programme of the National Cereals Research Institute (NCRI), Badeggi, was engaged to handle the development of the seed stock for the programme. Seven hectares of seed cane were thus established for the green fuels or E10 programme in 2007. However, the 20,000 ha land that was to receive the seed cane from NCRI was not ready in either of the primary sites for the E-10 programme in Nigeria up to date. On the other hand, in Egypt there are more than 15 by-products which are obtained in commercial production from the sugar industry of sugar cane in factories of Egyptian Sugar and Integrated Industries Company (ESIIC) such as paper, pulp and wood from bagasse as well as alcohol, vinegar, baker's yeast, perfume, medicine materials, glycerol and others from molasses and organic fertilizer from cane mud. Some of these bye-products are exported to other countries.

Lack of political will on part of governments

The Nigerian experience is not different from other Northern African countries as reported by Zuurbier and Van de Vooren, (2008) on the development of the ethanol market which indicates increasingly relevant position in sub-Saharan African countries that unfortunately have not yielded improved results in any one country. The problem is not the land and not the expertise on sugar cane production but on the non political will to translate good ideas into concrete establishment of large sugar cane farms and appropriate distilleries to produce ethanol from the grown sugar cane.

Lack of legislative control for illegal parasites

In most countries, working with some parasites is illegal because they are under legislative control. For example, it is illegal to work with potato wart disease *(Synchytrium endobioticum)* in much of Europe and North America, or with the Colorado potato beetle *(Leptinotarsa decemlineata)* in Britain, and the golden nematode *(Globodera rostochiensis)* in most of Canada (Dick, 1966). There is no such legislative control on any pest in Nigeria and or most other Northern African countries. Thus, active members are at liberty to intentionally introduce foreign parasites into areas where they were not known. The import of this scenario is that legislative protection is required for high productivity sugar cane in Nigeria and other North African countries. It is recommended that introduced materials (clones) of sugar cane to Egypt should be quarantined for pests and diseases under hard control in special isolated fields in research station of ESIIC.

Lack of breeders' royalties

The breeding of sugar cane varieties by breeders aided by crop protectionists takes a long period ranging from 8-10 years in Nigeria, other Northern African countries and other sugar cane growing nations of the world (Robinson, 1987). As is the case with lack of legislation for appropriate pricing for sugar cane, no sugar cane growers association, no protective legislation on sugar cane and sugar imports in Nigeria and in most other North African countries there is also lack of legislation for breeders' royalties for the seven bred sugar cane varieties by NCRI. Concerted efforts have not been made for the formation of relevant regional associations like African Sugar cane Breeders Association, African Pathologist Association etc to address the problems of breeders' royalties.

Lack of sustainability and certification schemes

Production of sugar cane is associated with serious negative environmental and social impacts. The expansion of this production in particular often leads to land right conflicts, rural unemployment and biodiversity loss through the conversion of natural areas. Sustainability schemes are often promoted as solution for prevention or managing negative impacts. The most relevant schemes for sugar cane are the Basel Criteria (BC), Better Sugar cane Initiative (BSI), the UK Renewable Transport Fuel Obligation (RTFO), Sustainability Standard (ST) and the Dutch Cramer Criteria (DCC) which exist to check the environmental and social problems created by expansive sugar cane production in EU, US and Brazil. Such systems are lacking in Nigeria and Northern African countries, except in South Africa, where for example, workshops held during 2004 and 2005 with all the major stakeholders including government policy makers, environmental NGOs and sugar cane growers resulted in the development of 'The Sustainable Sugar cane Farm Management System' (SuSFarMS). The system is designed to encourage sustainable sugar cane production through the implementation of better management practices (BMPs), which reduce the negative impacts on the environment (Glaz, 2003; Maher, 2007). The Egyptian sugar companies have started to apply and manage environmental issues such as industrial water treatments as a response to government environment laws.

All these schemes require consultation of relevant stakeholders, but little guidance is given as to which procedures should be followed which increases the risk of insufficient consultation, leading to spurring conflicts with local communities as may result in Nigeria and Northern African countries with weak government structures and land use planning (Maher, 2007; FARA, 2008).

CONCLUSION

There is great potential for increased production of sugar cane in Nigeria and Northern African countries with little or no plans to ensure its sustainability. Government policies to check or address the numerous problems usually associated with expansive sugar cane production as experienced by Brazil (Clay, 2004; 2005; FOEB, 2006; Gunkel *et al*., 2007; Smeet *et al*., 2008), which are yet to be concretized in Nigeria and Northern African countries.

While, there seem to exist national and regional schemes and set groups to improved and standardize research and development on sugar cane production (FARA, 2008) such bodies mostly exist on paper for lack of political will of Governments for sustainable actualization in these countries. Infrastructural inadequacy for land development, factory efficiency, technological skills for hectare yield increase in sugar cane production, capacity building in laboratory skills equipment development and field management practices of biotic and abiotic stresses and possible environmental pollution and other effects are key problems facing sugar cane production and productivity in Nigeria and Northern African countries. Deliberate policies backed with strong political will to set up and sustain infrastructures and technological structures by governments in Nigeria and Northern African countries are the way out for sustainable and expansive sugar cane production by these nations. Nigeria and Northern African countries are to ensure well-established research in biotechnology for the development of transgenic sugar cane varieties as a means of conferring suitable biotic and abiotic stresses which could contribute to sustainable expansion of the crop as is currently the case with the leading world cane growing country Brazil (Zuurbier and van de Vooren, 2008). Nigerian and Northern African scientists should embrace networking research and development to face identified problems negating sustainable sugar cane production efficiency, standard laboratory practice and skill acquisition and bye-product diversification especially fuel ethanol and sugar production which are catalysts for expansive sugar cane production in these areas. With (FARA) assuring stakeholders in the bioenergy sector and by extension, sugar cane industry, of offering its policy platform to discuss and fine tune biofuel policy options as well as developing strategies for African agricultural research and development with sustainable criteria that meet regional and international standards on expansive sugar cane production, Nigeria and North African countries are sure of being in a worthwhile venture. Finally, factory and professional groups and private sector participation in sugar cane production for sugar and biofuel use are the needed impetus for open and sustained expansive sugar cane productivity in Nigeria and Northern African countries.

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