FINGER MILLET (*Eleusine coracana* (L.) GAERTN) IN SUSTAINABLE FOOD SECURITY IN NIGERIA: A REVIEW

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Abstract: Finger millet is an important security crop but it is not popular in Nigeria. Although it is one of the most nutritious among all the major cereals and also a major staple food for millions of people, the crop has received less attention in Nigeria. The few farmers that accepted the crop in the country identified some problems associated with the production of finger millet –viz: striga problem, difficulties in differentiating between weeds and finger millet at early stage of growth, high labour requirement to crown it all the problem of blast no access to improved varieties or cultivars. It is therefore important to make the farmers aware first of the crop, its importance then source for improved cultivars agronomic interventions for finger millet inter crop it with ginger. Therefore, researchers need to look at the cropping system approach rather than on one single crop. Furthermore, development of proper value chains, regulated markets, establishment of production cooperatives, and various value addition initiatives should receive support so that demand can drive the cultivation.

Keyword: Finger millet, food security, improvement, Nigeria

Introduction

Food security in the developing world is one of the greatest global challenges, exacerbated by global economic upheavals and climate change. Despite our rich endowment of natural resources and various International Agricultural intervention programmes in the country, Nigeria's agricultural productivity is still generally low. In 2003, more than 93 percent of the population lived on less than $2 a day, and 17 percent on less than $1 a day and this assertion has not yet been disproved (IFAD, 2011). Most of these people are in rural areas. In spite of the progress achieved, there has been a recurrent concern on the prospect of hunger due to limitation of food production. The world population in the year 2000 was 6.2 billion and 8.5 billion by the year 2025 (Agrios, 1997; US Census Bureau, 2012). Unfortunately there is no a vaccine against hunger. People need to be adequately fed every day; hence the importance of a well-developed agriculture that rationally utilizes available natural resources together with the technological improvements resulting from scientific research.

In 1986, World Bank's report regarding "Poverty and Hunger" defined the food security as "access of all people at all times to enough food for an active and healthy life". In 2001, FAO (Food and Agriculture Organization) for a second time defined that the food security as a circumstance that exists when all people, at all times, have physical, social and economic right to use for sufficient, secure and healthful food that congregates their dietary needs and food preferences for an active and healthy life (FAO, 2001). The staple food grains in tropic and semi-arid regions of the world, particularly Finger millet in the desert can be a good choice to manage sustainable food supply. Finger millet provides a good yield in these areas because of its great adaptive nature in harsh environment, especially drought conditions (Holt, 2000; Mgonja, 2005). Taylor *et al.* (2006) extensively studied and explained its drought tolerance and considered millets as one of the most drought-tolerant cereal grain crops. The growth requirements are very limited as Finger millet not only withstand several abiotic factors like, unpredictable climate; limited and inconsistent precipitation and nutrient-depleted soils, but also it is somewhat less suffered from many biological agricultural constraints (Sharma and Ortiz, 2000; Maqbool *et al*., 2001). Sharma *et al.* (2002) emphasized the urgent requirement to improve those crops which are relevant to the small scale farmers and economically poor consumers especially in the developing countries. This important objective can be achieved by sincere efforts in the development of this somewhat neglected crop. However, there is an ease in cultivating finger millet in areas which are not conducive for other cereals, hence there would be no competition for resources. In the incident of drought, maize is prone to be shattered, but these drought tolerant small grain cereals such as finger millet are able to provide some food for survival (Rukumi *et al*., 2006). Hence, small grains (finger millet) are the possible candidates to do better than maize under a well-organized, supportive agenda in marginal areas of the world (Rukumi *et al*., 2006). However, Van Oosterhout (1995) signified some rewards for the growers of small grains over maize:

- A lesser quantity of flour is required to bake the main meal compared to maize;
- Small grains assured starvation for a longer period and gives added energy;
- The storage procedure of small grains is much better than maize that cannot be stored further than eight months. Local cost effective storage knowledge is also available for these millets while maize wants noxious organophosphate protectants, often too expensive by farmers;
- There is no need for the purchase of these seeds because seeds of several varieties of these grains are accessible for planting. These seeds can be exchanged with relatives and neighbors, hence omitting the need of procurement;
- In years of short precipitation, in a multi-cropped system, less quantity of grains will give some yield

especially when grown in a multi cropped system, whereas maize will be an absolute disappointment.

Despite the importance of finger millet, the crop has been reported to be one of the most neglected crops in the world (Anon., 1996). The crop has been neglected by national and international research organizations and major donors to Agricultural research particularly in Africa compared to the research grants given to rice and maize in this region (Anan, 1996; Mgonja, 2005). It is a completely neglected and underutilized crop in Nigeria. Its production is left in the hands of peasant farmers.

Finger millet remains unknown and unstudied in Nigeria which led to difficulties encountered during its production resulting in low yield and it's becoming extinct. Report shows a progressive decrease in the few areas under the cultivation of finger millet since most of the local farmers go in to the production of other cereal crops like maize, rice and sorghum (Glew *et al*., 2008). In this review, attempt has been made to highlight finger millet production, utility, constraints and the way forward.

Finger millet production

Finger millet (*Eleusine coracana* (L.) Gaertn) originated in the highlands of Uganda and Ethiopia in east Africa (Anan, 1996). It is an important minor cereal crop extensively cultivated in wide geographical zone of the world, ranging from tropical and subtropical regions of Africa and India. The world's annual production of millet which includes finger millet stands at about 29.87 million metric tonnes out of which Nigeria produced 5million metric tonnes. Nigeria is the second world's largest producer (Table 1) after India who produced 10.91 million metric tonnes, followed by Niger, 2.95 million metric tonnes (FAO, 2013). Anon (1996) reported that world's annual production of finger millet stands at 4.5 million metric tonnes of grain of which Africa produced 2 million metric tonnes. Africa accounts for 8% of land area and 11% of total millet production worldwide (Glew *et al*., 2008). The crop is primarily a subsistent staple cereal food for millions of people in the dry lands of East Africa, central Africa and Southern India (Holt, 2000; Mgonja, 2005).

In Nigeria, according to Glew *et al.* (2008) the crop is cultivated in Southern part of Kaduna state in the Northern Guinea savanna and in the highlands of Jos Plateau in the north central Nigeria. From survey the crop has been found to be cultivated in Kano, Gombe, Bauchi, Nassarawa and Abuja (Umar and Kwon–Ndung, 2014). Finger millet is a tufted annual grassy plant growing to 40-150 cm height. It has erect compressed and glabrous stem capable of producing many tillers and nodal branches. The plant has narrow grass like leaves. The leaf-blades are linear and taper to an acute point, folded and striated and often have ciliated margins (Dida *et al*., 2007). The head (panicle) consists of a group of digitally arranged spikes hence the name finger millet (Fig. 1). The spikelets are made up of 4 – 10 florets arranged serially on the finger. All florets are perfect flowers with the exception of the terminal ones which may sometimes be infertile. The crop is about 97 – 99 % self pollinating, with spikelet producing seeds which are globose or spherical in shape, smooth and may be brown, reddish- brown, black white, orange or purple colour (Dida *et al*., 2007). Depending on the variety it takes 3 -6 mouths to mature (Dida *et al*., 2007; Shinggu *et al*., 2012; Gani, 2015). The yield of finger millet ranges between 500 – 750 kg on farmers field across Africa which is quite low (Takan *et al.*, 2004).

Table 1: Global production of millets in thousands per ton

Country	2010	2011	2012	2013
India	13293000	12660000	10750000	10910000
Nepal	2999523	302691	315067	305588
Nigeria	5170430	2711000	5000000	5000000
Sudan	471000	634000	378000	1090000
Uganda	267973	292000	244000	228000
South Africa	6900	7000	6500	6700
Ethiopia	634826	651851	742297	807056
Senegal	813295	480759	661673	572155
USA	261610	207500	70084	418145
Zimbabwe	50999	60000	44000	5500

Source: FAO (2013)

Fig. 1: Finger millet plants showing the finger-like heads

Importance of Finger millet

Finger millet is an important minor cereal crop with very high nutritional and medicine values. These are attributed to its high polyphenol, dietary fiber, minerals and essential amino acids (Mckeown, 2002). Epidemiological studies have revealed that regular consumption of whole grain and their products can protect against the risk of cardio-vascular diseases, type ii diabetes, obesity, gastro-intestinal cancers, anti- tumerogenic and atherosclerogenic effects, anti oxidant and microbial properties, and so many other disorders (Mckeown, 2002), The crop contains important starch fractions which are slowly digested and absorbed and are good in the diet for metabolic disorders such as diabetes hypertension and obesity (Sharavathy *et al.,* 2001). Thacher *et al.* (2000) and Vanderjagt *et al.* (2007) reported that finger millet contain high level of methionine, tryptophan, vitamin B, fibre and minerals such as phosphorus and iron, it contains 40 times calcium level more than that found in maize (*Zea mays* L.) and rice (Or*yza sativa* L.) (Table 2), 10 times more than that found in wheat (*Triticum estivum* L.). Looking at the medicinal and nutritional value of the crop, it is a good source of balance diet formulations for diabetic patients' pregnant women, nursing mothers, children, people leaving with HIV and malnourished people. Malted product is used for weaning babies/infant food (Malleshi, 2005). High level of iron and calcium content of finger millet (Table 2) has been found to be relevant to people in northern Nigeria where the incidence of iron deficiency causes anemia, especially in pregnant women (Vanderjagt *et al*., 2007), and calcium deficiency causes rickets in young children (Vanderjagt, 2001; Thacher *et al*., 2000). The crop has the ability to grow well in water deficit regions, it has the capacity to store for a period of over 10 years, the grain is also resistant to mould and insect pest

attack. All these put together makes the crop a viable emergency food as it fits well in to the farmers risk avoidance strategies in drought prone areas (Holt, 2000).

Table 2: Comparative nutritional quality between finger millet and other food grains

Component	Maize	Rice	Finger millet
Food energy (Kcal)	408.0	406.0	334.0
Protein (g)	10.5	8.1	7.3
Carbohydrate (g)	83.0	90.0	74.0
Fat (g)	5.3	0.7	1.3
Fiber (g)	3.2	0.3	3.2
Ash (g)	1.3	0.7	2.6
Thiamine (mg)	0.43	0.08	0.24
Riboflavin (mg)	0.22	0.06	0.11
Niacin (mg)	4.1	1.8	1.0
Calcium (mg)	8.0	32.0	358.0
Copper (mg)	0.35	0.25	0.5
Iron (mg)	3.0	0.9	9.9
Magnesium (mg)	142.0	130.0	140.0
Manganese (mg)	0.55	1.1	1.9
Phosphorus (mg)	234.0	130.0	250.0
Potassium (mg)	320.0	130.0	314.0
Sodium (mg)	39.0	6.0	49.0
Zinc (mg)	2.5	1.2	1.5
Essential amino acids (grams per 100 g protein)			
Cystine	1.8	2.0	1.7
Isoleusine	3.6	4.3	4.0
Leusine	12.3	8.3	7.8
Lysine	2.8	3.6	2.5
Methionine	2.1	2.4	5.0
Phenylalanine	4.9	5.3	4.1
Threonine	3.8	3.6	3.1
Tryptophan	0.7	1.2	1.3
Tyrosine	4.1	3.3	4.1
Valine	5.1	6.1	6.4

Source: National Research Council (1996)

Finger millet is consumed in different forms of food product similar to those made from sorghum and other millets (Styslinger, 2003). This product ranges from fermented and non fermented porridges, pancake-like flat breads and fermented alcoholic with its amylase enzymes which readily convert starch to sugar, and subsequently to alcohol and non- alcoholic beverages (drinks) (Takan *et al*., 2002). Among the tropical cereals, finger millet produce the best quality malt for local brewing and is preferred than maize and sorghum. The malt has good taste, easily digested, rich in amino acids and also an ideal food for people of all age groups (Anon., 1996). Finger millet is an important crop in the livestock industry. It is a source of good fodder and contains up to 61% of total digestible nutrients, which is higher than pearl millet (*Pennisetum americana*), wheat (*Triticum aestivum*)or sorghum (*Sorghum bicolar*) *(*Anon, 1996; Upadhyaya *et al.,* 2006). The by- product from brewing has been reported to be a good source of fibre, minerals and protein for poultry and suitable for breeding stock (Obilana and Manyasa, 2002).

Constraint to Finger millet production

Finger millet production constraints can broadly be categorized as socio-economic, biotic, abiotic and policy considerations (low research consideration).

Socio–economic consideration

Lack of awareness

Finger millet is one among the lost crop of the world. It has been grossly neglected both scientifically and internationally. Most of the world has not had of it and even those countries that grow it to languish in limbo of a ``poor person's crop'', a famine food or even worse a ``birdseed''. Although it is one of the most nutritious among all major cereals and is a major staple food for millions of people in East and central Africa and southern India. Even people that know and grow the crop are not aware of its nutritive values and so consider it as an inferior crop to maize rice and wheat. People are not aware of how to utilize the crop. There is no technical information about the crop.

Economic consideration

Finger millet production is labour intensive relative to other crops and this has limited expansion in acreage as it covers only 0.43 ha per household of the average land holding of 7.6 ha in eastern Uganda (Kidoido *et al*., 2002). The small seed size also contributes to complication in its cultivation (Anon, 1996) as it necessitates planting in well-made and fine seed beds at higher plant densities (especially where it is planted by broadcasting). Most of the finger millet is produced by low income farming families. They have little or no input with limited labour normally constituted by family members for production. Poor resource farmers hardly apply fertilizer to finger millet. It is therefore necessary to increase production and farmer's income through genetic improvement of finger millet, enhanced access to quality seed, better agronomic practices, and empowerment in knowledge and access to input.

Biotic factor

Among the biotic factors are weeds, pests and diseases. There is a high weed pressure and the most important ones are *Striga* and wild millets which have been associated with decline in soil fertility. High weed pressure is a great problem in Finger millet production. First the seedlings are slow growing and require weed free environment to be able to compete favorably with weeds. Unfortunately at the early stage of growth it is difficult to differentiate between finger millet, grass and sedges. The difficulty in weeding is further complicated by wild relatives of the crop (for instance, *Eleusine indica*) that look like finger millet at the time of weeding. It takes a skilled observer and close examination to differentiate them. The problem of weed management is compounded by the practice of planting the crop by broadcast of seeds.This makes weeding operations labour intensive, tedious, time-consuming and uneconomical for farmers. The high prevalence of *striga* is association with finger millet further pose a serious challenge as effective means of *striga* control is still lacking.

Blast is one of the major fungal diseases of finger millet because of its aggressiveness. It reduces the quality of finger millet grain and is responsible for yield losses of between 10 and 80% in Nigeria and elsewhere (Holt, 2000; Obilana, 2002; Takan *et al*., 2002; Sastri, 1989; Tenywa *et al*., 1999; Kidoido *et al*., 2002; Oduori, 1998; (Bulus, 2002). It affects finger millet at all stages of growth. It is a disease caused by fungus *Magnaporthe grisea* (Anamorph: *Pyricularia grisea*). A number of grasses and sedges are attacked by this fungus as alternate host. Blast can result in poor grain filling thus drop in yield.The principal insect pest problems in millet production are grasshoppers and army worms. Sometimes shoot fly, stem borers and clinch bugs or false clinch bugs may also cause economic damage but these can be controlled by insecticides. Birds are also important pests, especially, the notorious *Quelea quelea* and other small grain feeding birds.

Abiotic factor

Among the abiotic factors are the unpredictable rainfall patterns and reduced soil fertility. Drought reduces leaf area, dry matter accumulation, seed weight, radiation use efficiency and yield of finger millet. Soil fertility depletion is also a major cause of declining yield in Nigeria. Farmers grow finger millet without applying fertilizer in Nigeria on soils that are nutrient deficient due to high cost. There is need for more drought tolerant finger millet varieties with good tiller production, medium plant height with strong straw to avoid loading. There is also need to develop complete management package to encourage the production of the crop.

Policy considerations (low research consideration)

In terms of policy, finger millet is grossly neglected both nationally and internationally in terms of research, compared to crops like maize and rice (Oduori, 2005), and this has resulted in use of unimproved, low yielding, disease susceptible cultivars which are also responsible for the low yields observed in finger millet. Most part of the world is ignorant about the crop and those countries that know it have left the production in the hands of poor resource farmers. The general attitudes toward finger millet need to be reversed.

The Way Forward

Blast management

Finger millet blast is characterized by the appearance of lesions on the leaver nodes and heads. The disease can be controlled or managed through the use of resistant varieties. Chemical control measures can also be used though expensive. Integrated management can also be used. This is the integration of the various control measures into a package. Research should also be conducted to know the alternate host of the crop among weeds.

Variability

Germ plasm identification and characterization is an important link between conservation and utilization of plant genetic resource. It will be a good idea if existing germ plasm accessions of finger millet can be collected and their morphology characterized in Nigeria. It is important to understand whether genetic variation exist in the germ plasm to be improved and whether the variation can be transmitted from parent to off spring (Falconer, 1996). It is also important to understand the amount of genetic gain that can be expected from successive generations of the offspring. Some studies had been conducted to understand variability, hereditability and trait association in finger millet, in some regions. There is therefore need to conduct such studies on Nigerian condition especially for trait preferred by farmers.

Genotype and environment interaction, adaptability and yield stability

Finger millet is grown in very few places or agro-climatic zones which are highly variable resulting in complex genotype and environment interactions. The performance of varieties and identifications of blast disease resistance should therefore be evaluated in multi-location trials to determine performance, the yield and blast disease resistance, yield stability and to provide a reliable guide for selection of the best genotypes for yield. Andrews (1993) advocated for testing environments in finger millet. Stable varieties can perform better under small scale farmer's conditions of stress, low inputs and therefore sustainable genotype and environment interaction according to Ramagosa and Fox (1993) is the differential genotypic expression across environments which may determine the breeding strategy to be adopted, that is, whether the aim is for specific or broad environment adoption.

Cropping system approach in promoting agronomic package of practices for finger millet

Improvement of agronomic practices in finger millet is a must for encouraging farmers for continued cultivation. The new cultivation practices should address the issues related to labour requirement and the drudgery faced by the farmers, especially women farmers. The varieties that exist are the traditional old ones. Very few farmers grow finger millet on a very small scale. In Kaduna State, farmers inter crop it with ginger. Therefore, researchers need to look at the cropping system approach rather than on one single crop.

Create market incentives to increase domestic production of finger millet

A Development of proper value chains, regulated markets, establishment of production cooperatives, and various value addition initiatives should receive support so that demand can drive the cultivation. Value addition through product diversification is another option to increase demand.

Conclusion

Increased awareness of finger millet is necessary in Nigeria, to encourage people on the production and consumption of finger millet products. The dietary fiber and polyphenols in finger millet are known to offer several health benefits such as antidiabetic, antioxidant, hypocholesterolaemic, antimicrobial effects and protection from diet related chronic diseases. Regular consumption of finger millet as a food or even as snacks helps in managing diabetes and its complications by regulation of glucose homeostasis and prevention of dyslipideamia. This review provides nutritional and medicinal awareness of finger millet which has a high potential to contribute to food security in Nigeria.

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