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Review paper

Potential Role of Biotechnology Tools for Genetic Improvement of Africa Underutilized Crop: The Case of African Yam Bean (*Sphenostylis stenocarpa*) (Hochst. Ex A. Rich.) Harms)

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ABSTRACT: African yam bean (*Sphenostylis stenocarpa*) is an underutilized and neglected legume cultivated in Africa. It is considered as one of the lost crop of Africa, but important food crop for millions of people in Africa. The current Corona virus (COVID-19) pandemic that has affected economy around the world, has also affected the farming system in developing countries. Farmers are no longer able to physically go to farms. The impact has been dramatic as farmers scramble to put in place workable short terms solution for continuous farming activities and food production particularly in African where farmers face additional challenges relating to finance and available infrastructures. It has become apparent to advance agricultural knowledge and technology for the production of sufficient and affordable food. Research has a role to play in the production of sufficient food for the world population. This review shows that further study on the use of Biotechnology to improve the genetic makeup of the African yam bean for higher productivity in order to meet the food needs of the growing population has become imperative.

Keywords: African yam bean, *Sphenostylis stenocarpa*, food, biotechnology

INTRODUCTION

Food insecurity remains one of the major problems of the world, and with the emergence of the deadly Corona virus (COVID-19), which has affected almost all the sectors of most developing countries of the world, particularly the agricultural sector. Farmers are no longer able to physically go to farms. The impact has been dramatic as farmers scramble to put in place workable short term solutions for continuous farming and food production. The African yam bean (AYB) is an underutilized and neglected crop cultivated in East, Central and West Africa. Although rich in nutrients, its anti-nutritive factors, long maturity time and hard-to-cook natures makes it unfavorable for farmers (Ijarotinu *et al*., 2014).

It is considered as a threatened germplasm (FAO 1991; Ademola *et al*., 2020). Food and Agriculture Organization and World Health Organization have described the amino profile of AYB as being comparable with those of whole hen's egg as reported by Adewale and Dumet (2010). The African yam bean has the potential of fostering food security in Africa due to its nutritional qualities and resistance to pest infestation. The AYB has been used by many to complement, supplement, fortify and enrich several staples such as breakfast meal (Idowu, 2015). A vital requirement therefore will be to review the use of potential biotechnology tools in enhancing genetic improvement of the AYB as several factors are responsible for the general decline in AYB production.

Some of the major disadvantages of AYB are hard testa, longer time to cook, high cost and energy on cooking, long maturity time and shattering (Adewale and Dumet, 2010).

The AYB improvement: status, constraints and prospects

The increasing problem of food insecurity in Africa due to the emergence of the COVID-19 has given recognition to AYB as a potential buffer against famine. The scientific challenge is to develop new improved high-yielding and non-shattering varieties of AYB with larger seeds size**,** soft testa to reduce cooking time and energy, shorter growing time and with seed quality (Olasoji et al., 2011). Currently, the genetic improvement of AYB centers generally on germplasm collection and their morphological characterization with the objectives of understanding the broadening of their gene pool. In Nigeria, it is reported that over 30 different accessions of AYB have been collected and are being evaluated to identify those that could be utilized in breeding programme (Klu *et al*., 2001). However, the conventional morphological characterization alone might not provide the much needed information on the evaluation, origin, distribution and diversity of AYB. Also, the development of improved AYB accessions by the traditional method of hybridization appears not feasible due to the general dearth of information on its biology (Abioye *et al*., 2015). This has become imperative to exploit other alternative techniques like biotechnology to improve the gene pool and facilitates the development of improved varieties. The recent progress in the application of biotechnology tools for genetic improvement of cereals (Repellin *et al*., 2001) give hope for AYB genetic improvement.

Application of DNA markers for AYB germplasm characterization

Breeders need access to a wide range of accessions with agronomic features like maturity, seed size, soft testa to shorten cooking time, and high yield potential in order to generate new better varieties. The key to a successful genetic improvement programme is the collecting and conservation of native and exotic AYB material in a gene bank. Traditionally, the AYB germplasm has been studied using a number of phenotypic features that necessitate lengthy observations.

Environmental factors, on the other hand, frequently influence phenotypic traits. DNA markers such as SSR, CRISSP, RAPD, RFLP, and AFLP are now available to help in gene pool analyses. Random amplified polymorphic DNA (RAPD) markers have been widely employed for genetic mapping. RAPD and AFLP have been demonstrated to be efficient DNA markers for characterization of various rice genotypes in rice (Jackson, 1999). These markers could be useful for identifying AYB accessions' DNA. The next step is to launch a research effort to test numerous primers for their capacity to create polymorphism in AYB genomic DNA. The primers that produce polymorphic bands on gels might then be used to examine the entire AYB germplasm.

Expanding AYB gene pool through somaclonal variation

Genetic variability for agronomically important traits is frequently low among farmed germplasm. Biotechnology technologies such as somaclonal variation may allow for the expansion of the AYB gene pool for features such as maturity, short growing season, reduced cooking time, and large seed size. Somaclonal variation is a type of genetic variation that can emerge during in-vitro culture of somatic plant cells and tissues over an extended period of time (Larkin and Scowcroft, 1981).

In general, somaclonal breeding in seed and cereal crops entails the induction of embryogenic calli from exercised embryos of adult caryopses and the selection of somaclones in the induction or regeneration medium, or even both. However, the genetic variety that develops during somaclonal variation is normally minimal, although it could be increased by using chemical mutagens or irradiation. These novel approaches could be used to improve the genetics of AYB. However, the promise of exploiting somaclonal variation in AYB genetic improvement is heavily reliant on the availability of an efficient methodology for inducing AYB embryogenic calli. Using this biotechnological approach, thousands of AYB somaclonal variations can be created. Breeders can then test these somaclones to find new plants with desirable agronomic features. The findings of such research are expected to illustrate the importance of biotechnology in advancing research on African native crops.

Genetic transformation

Genetic transformation, of all biotechnology technologies, has the best opportunity of breaking through the breeding barrier and producing superior crop types. Target crops must be carefully chosen if there is to be any genuine influence on food security in Africa. At the moment, no African crops vital to the continent's food security have been sold as transgenic crops. As a result, the AYB could be an excellent candidate for proving the value of genetic transformation in crop development.

Because the AYB is a legume, it may benefit from existing genetic transformation procedures. The inherent low yielding potentials of existing unimproved landraces, hard testa, seed shattering, and extended maturity period are now hindering mass production of AYB in Africa (Olisa et al., 2010). Large seed size and yield could be achieved with AYB genetic engineering, increased photosynthetic efficiency, and improved carbon partitioning. Transgenics with soft testes could possibly be developed as a result of genetic transformation.

Conclusion

The AYB is an important food crop for most developing-world communities. Despite the difficulties in breeding this crop, its primary importance as a protein source with a variety of nutritional and health benefits cannot be overlooked. To meet the world's food demands, legume crops like the AYB must continue to improve. However, genetic development of these crops is limited by a number of issues, including low yield, extended maturity period, pest and disease, low market value, and unimproved production technologies, which are to blame for the reduction in the production of African food crops. For example, the AYB has issues with small seed size, low yield, hard testa, shattering, and a long maturity period.

The genetic enhancement of AYB may necessitate the collection of available AYB accessions from all of Africa's AYB growing regions in a gene bank for study of its evolution. The traditional method to germplasm characterization, which is based primarily on morphological characteristics, must be supplemented with the biotechnology tool of molecular markers. DNA markers used to research rice diversity, such as RAPD and AFLP, could potentially be employed to evaluate AYB germplasm. The findings of such an inquiry will give crop improvement specialists with the knowledge they need to select appropriate AYB accessions for use in hybridization programmes. Alternative approaches, such as somaclona variation, hold a lot of promise in the generation of genetic variations in AYB, especially when combined with mutation induction. The procedures for cereal tissue culture that are currently accessible could be used to create AYB somaclones. Genetic transformation is another potent technological approach that could help overcome the AYB breeding obstacles. This tool uses a "gene-gun" or Agrobacterium tumefaciens to transfer a foreign gene from one organ to another. The genetic transformation strategy might be used to develop transgenic AYB with high photosynthesis and carbon portioning efficiency, which could result in larger seed size and higher yield resistant to insects and soft testa.

The gene for constructs for such traits is readily available and has been used for several Cereal crops which make the genetic transformation of AYB a feasible project. Therefore, Agricultural biotechnologist should pay attention to underutilized crop such as the AYB to enhance its genetic improvement, thereby encouraging its expanded production in Africa.

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