Breeding for Continuous Storage Root Formation and Bulking in Sweetpotato

Fig 1. Continuous storage root formation and bulking expression. The storage roots are many at different sizes and at different maturity periods (Credit: A. Bararyenya)

- Research conducted on diverse sweetpotato germplasm showed that some genotypes form their roots at the same time, that are of the same maturity (discontinuous storage root formation and bulking) and other continue to form roots over time (continuous root forming), which aligns with the traditional practice of piecemeal harvesting.
- The genetic control of these two types is different and their cross combination permitted transgressive segregant progenies, which may form the basis for developing superior varieties.
- Molecular markers, as well as putative genes for the two types of growth have been discovered and will serve as foundation knowledge for accelerating breeding for the traits through marker-assisted selection.

SASHA Sweetpotato Action for Security and Health in Africa

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What was the problem?

Sweetpotato (*Ipomoea batatas* (L.) Lam) is an important crop in sub-Saharan Africa (SSA) where breeding research is being undertaken to improve varietal adaptation to different environmental conditions, yield and storage root nutritional quality. The ability to continually form storage roots during the course of the growing season and bulking, referred to as continuous storage root formation and bulking (CSRFAB) is a potentially useful aid to breeding, as it aligns with the traditional practice of piecemeal harvesting. Farmers practicing piecemeal harvesting remove the larger roots as they mature, leaving more space behind from the smaller roots to continue to enlarge. Piecemeal harvesting is a practice suited to CSRFAB varieties (Fig. 1) and is recognized as important in SSA. Smit (1997) found that the total yield and undamaged yield for the piecemeal harvesting treatments were comparable to the yields at the optimum harvest times for once-over harvesting at 6-7.5 months after planting. Furthermore, her results indicated that piecemeal harvesting is a practice with a positive controlling effect on weevil infestation.

However, due to the manner in which sweetpotato breeding has developed, focused on collecting yield data at a single time harvest, the recognition that this might bias against selecting clones exhibiting CRSFAB has received little attention. This lack of attention to piecemeal harvesting may have led to the release of newly bred sweetpotato varieties that are not widely adopted and/or the continued use low yielding local varieties just because they possess the continuous root formation trait. Furthermore, the genetics underlying CSRFAB traits make them amenable to breeding for sustainable integration of such "perennials" into annual-based systems, with complementary parallel breeding and complementary parallel management.

What objectives did we set?

Yield is a complex characteristic, yet it is typically the most important breeding objective for all crop types. The desired yield increase, as well as stability, are closely linked to many other breeding objectives, such as cultivation properties, resistance or nutrient efficiency. A desired yield can therefore be achieved in different ways, however, minimizing crop loss while maximizing crop yield are driving key goals. Thus, the specific objectives were:

I. to estimate the genetic variability of CSRFAB in sweetpotato cultivars in Uganda;

II. to discover genetic markers and associated putative functional genes for CSRFAB trait to speed up sweetpotato improvement;

III. to determine the general and specific combining ability of parents, heritability and the components of heterosis of CSRFAB in sweetpotato.

Where are we working?

We are working at key mega-environments in Uganda with the expectation that our findings, germplasm, and methods will serve not only Uganda, but other parts of sub-Saharan Africa. Our breeding efforts (Fig.2), have been mainly carried out at the National Crops Resources Research

Fig 2. Field trial partly harvested with other roots remaining for subsequent harvests (Credit: A. Bararyenya)

Fig 3. Discontinuous storage root formation and bulking expression. The storage roots are few and similar in size at the same maturity period (Credit: A. Bararyenya)

Institute (NaCRRI), Namulonge) and the National Semi-arid Resources Research Institute (NaSARRI), Serere. The marker discovery research was carried out at the Biosciences for East and Central Africa (BecA) facility in Nairobi, Kenya.

What did we achieve during SASHA Phase 2?

Sweetpotato trials conducted for the past four years have demonstrated that CSRFAB is an important trait, is measurable, varies among sweetpotato cultivars and can be directed towards breeding high yielding varieties to suit sweetpotato agricultural patterns and needs. Achievements so far highlighted potential increase of 117% in yield by using CSRFAB cultivars compared to using those which form few roots at a similar time or discontinuous storage root formation and bulking (DCSRFAB) (Fig. 3).

Twelve and seven genetic markers for CSRFAB and DCSRFAB, respectively, as well as their putative functional related genes have been discovered in this study, which will enable speed breeding of the trait (Fig. 4). Crossing CSRFAB and DCSRFAB genotypes resulted in a significant heterosis increment in the hybrid offspring, leading to transgressive segregation, which is key for the development of superior hybrid varieties. The genetic gain achieved for yield is about 2 t/ha per generation which indicates the progress plant breeders can make in offspring (filial 1 or F1) by crossing CSRFAB and DCSRFAB sweetpotato parental genotypes. Such huge genetic gains for a single generation highlight the importance of CSRFAB trait for improving sweetpotato yields.

What's next?

Selection intensity of 10% was applied to the F1 population while exploiting heterosis performance between DCSRFAB and CSRFAB parental genotypes. Evaluation of these trials continues, aimed at releasing CSRFAB varieties in Uganda. Systematic integration of the CSRFAB trait into the sweetpotato breeding program in Uganda has been recommended. The goal would to be to have significant yield improvement and food security for smallholder producers. Promoting the adoption of the CSRFAB trait for other sweetpotato breeding programs is the next step. Discovered markers for CSRFAB will be validated for potential marker-assisted selection deployment for the trait.

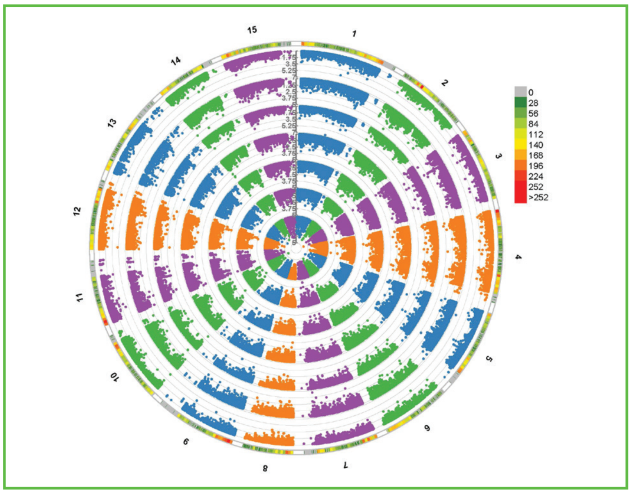

Fig 4. Circular Manhattan plot for association of SNP with continuous storage root formation and bulking. The dashed blue line indicates the different genome-wide significance level [−log10 (P)]. The dots over the blue lines indicate genome-wide significantly associated SNP. The Manhattan plots cover, 90DAP, 120DAP, 150DAP, 180DAP, slope, AUGC, and intercept, respectively, moving to the center.

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Institut des Sciences Agronomiques du Burundi (ISABU), Bujumbura, Burundi.

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