NEXTGEN CASSAVA

NextGen Cassava Project

Summary Report 2020

Reporting period: April 1, 2019 - March 31, 2020

Breeding Milestone: Germplasm exchange: **Collaboration and exchange of indexed germplasm with Latin American breeding programs enable the introgression of genetic variability into African breeding populations.**

Year 2 targets: At least 20 seeds from at least 50 selected genotypes shipped to Africa (CIAT); 500 botanical seeds of 10 wild cassava species transferred to Africa (Embrapa)

Summary Report: We met the target. In total, 5,076 full-sib seeds from crosses between progenitors with CMD and **whitefly resistance**, 6,481 full-sib seeds from crosses between progenitors with CMD resistance and **high beta-carotene**; and 55,497 half-sib seeds from progenitors with CMD and high beta-carotene. All these seeds were shipped to IITA in Sep. 2019.

Detailed Report: The Genebank at CIAT maintains 6,155 cassava accessions. From the genebank, add-value traits were identified, including high beta-carotene, CMD and CBB resistance, good cooking quality, low cyanide, whitefly resistance, high and stable starch, waxy starch and CBSD resistance. All these add-value traits are being integrated into the elite varieties in the breeding program at CIAT. Progress has been made, especially in increasing beta-carotene content. Due to the damage caused by CMD, these improved breeding materiasl can not survive to produce flowers in the field in Africa. Here, our objectives are to produce seeds combining these add-value traits and CMD resistance and deliver them to African partners.

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Table 1. Number of seeds of different traits delivered to IITA in 2019 September.

year	trait1	trait 2	family type	number of family	number of parent	number of seeds
2018-2019	beta-carotene & low cyanide	CMD	full-sib	32	21	897
2018-2019	beta-carotene & cooking quality	CMD	full-sib	83	47	3,548
2018-2019	beta-carotene	CMD	full-sib	96	74	2,036
2018-2019	beta-carotene	CMD	half-sib	43	43	55,497
2018-2019	whitefly	CMD	full-sib	82	27	5,076

In the Cassava Whitefly project, we identified **whitefly resistant** clones from the genebank. These whitefly resistant clones were used as progenitors to produce seeds with both whitefly resistance and CMD resistance. The whitefly resistance clones were crossed with CMD resistant clones. Their progeny was selected for whitefly resistance using high-throughput phenotyping and CMD resistance using SNP markers in InterTek. The selected clones were used as progenitors to produce seeds for IITA. Among the two progenitors of eahc cross, at least one progenitor has CMD or whitefly resistance. In total, 5,076 full-sib seeds were generated and delivered to IITA in September 2019 (Table 1)

In the 2019-2020 pollination season, we were mainly focused on two traits CBSD resistance and high dry matter (erect plant type). The seeds from the crosses with CMD resistance clones were harvested. Now, we are cleaning and counting the seeds, which will be sent to IITA before September 2020. Here, we report the full-sib seeds harvested from the crosses between clones with **CBSD resistance** and clones with CMD resistance (Table 2).

From the 15 CBSD resistand clones initially reported by Dr. Stephan Winter, we were able to cross five clones, (COL40, PER221, COL144, PER353 and PER226) with CMD-resistant clones. In total, we harvested 946 full-sib seeds. The seeds will have three destinations 1) About 15 seeds from each of 18 full-sib families with be sent to Dr. Stephan Winter; 2) Most of the left seeds will be sent to IITA; 3) a bi-parental population with 207 seeds from the cross between COL144 and C33 will be used for mapping QTL for CBSD resistance at CIAT.

Work Plan 1. In total, 258 seeds will be sent to Dr. Stephan Winter in June 2020. The CMD and CBSD resistance will be tested by Dr. Stephan Winter. The seeds will serve at least three purposes, i) to uncover the segregation of CBSD resistance and understand the inheritance of CBSD resistance in progeny; ii) to test the CMD resistance in progeny, and in turn to confirm the CMD resistance of progenitors; iii) to identify clones with both CMD and CBSD to deliver to African breeding programs. The seeds are ready for shipping to Dr. Stephan Winter.

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Table 2. Full-sib seeds harvested from the crosses between CBSD and CMD resistance in 2019-2020 pollination season.

Materal	Paternal	trait_M	trait_P	Seeds	for Stephan	for IITA
COL 40	C 33	CBS	CMD	8	8	
COL 144	GM 7672- 5	CBS	CMB	3		3
COL 144	GM 7673- 3	CBS	CMB	44	15	29
COL 144	GM10055B- 1	CBS	CMB	24	15	9
COL 144	GM10055B- 2	CBS	CMB	21	15	6
COL 144	C 19	CBS	CMD	48	15	33
COL 144	C 33	CBS	CMD	15	15	
COL 144	C 39	CBS	CMD	38	15	23
GM10054B- 1	PER 221	CMB	CBS	21	15	6
GM10054B- 1	PER 226	CMB	CBS	7		7
GM 7672- 5	PER 226	CMB	CBS	4		4
C 19	PER 226	CMD	CBS	1		1
GM 6125- 13	PER 353	CMB	CBS	4		4
GM 7671- 8	PER 353	CMB	CBS	1		1
GM 7672- 5	PER 353	CMB	CBS	6		6
GM 7672- 8	PER 353	CMB	CBS	5		5
GM 7673- 3	PER 353	CMB	CBS	17		17
GM10054B- 1	PER 353	CMB	CBS	30	15	15
GM10054B- 1	PER 353	CMB	CBS	25		25
GM10054B- 2	PER 353	CMB	CBS	72	15	57
GM10054B- 2	PER 353	CMB	CBS	5		5
GM10055B- 1	PER 353	CMB	CBS	1		1
GM10055B- 2	PER 353	CMB	CBS	56	15	41
GM10062- 1	PER 353	CMB	CBS	32	15	17
C 19	PER 353	CMD	CBS	29		29
C 33	PER 221	CMD	CBS	14	14	
C 33	PER 353	CMD	CBS	32	15	17
C 39	PER 353	CMD	CBS	12	12	
C 243	PER 353	CMD	CBS	15	15	
C 413	PER 353	CMD	CBS	51	15	36
PER 353	GM 7673- 3	CBS	CMB	14	14	
PER 353	GM10054B- 1	CBS	CMB	20		20
PER 353	C 19	CBS	CMD	32		32
PER 353	C 33	CBS	CMD	6		6
PER 353	C 33	CBS	CMD	26		26
				739	258	481

For the bi-parental population from COL144 and C33, we germinated the seeds in tissue culture and will produce *in vitro* plants. Once we get the results from Dr. Stephan Winter, and make sure the progeny showed segregation in CBDS resistance/immunity, we will send the *in vitro* plants to Dr. Stephan Winter for CMD and CBSD screening. Our team members in the lab can come back to work (after the Covid-19 lock-down) , so we are able to complete the activities on schedule.

Work Plan 2 To minimize the effect of COVID-19 on the availability of labor for the pollination season 2020-2021, we established three polycrossing nurseries, i) high dry matter, CMD and CBSD; ii) good cooking quality, CBSD and CMD; iii) beta-carotene, CBSD and CMD. Paired crossing nurseries under natural light and extended photoperiod were also established in Palmira, Colombia. COVID-19 has little impact on our activities to generate seeds for African partners.

Breeding Mileston: GS predictions: Genomic Estimated Breeding Values and Genomic Estimated Total Genetic Value used to select clone for crosses and advancements in the breeding pipelines.

Year 2 targets: 30-50 parents selected for crosses; 100-300 clones selected for advancements to PYT, AYT and UYT.

Summary Report We met the target; 45 parents with high dry matter, good cooking quality or CMD resistance were selected and crossed, and more than 10,000 seeds were harvested for developing varieties with high dry matter content, good cooking quality and CMD resistance.

Detailed Report A genomics-assisted breeding scheme was proposed for cassava breeding at CIAT, where we will use a subset of the breeding population to train genomic selection models, which will be used to predict the breeding values of the remaining breeding population (Figure 1). We expect the benefits of implementing the genomics-assisted breeding scheme as follows: i) Reduced genotyping cost by reducing the population size from 25,000 to 2,000 based on their field performance (cost ~$2 per clones); ii) Multiple trait-based selection made at the early stage, F1C1, because intensive phenotypic data will be collected to develop prediction models for multiple traits; iii) Dramatically reduced population size at the early stage, F1C1. Clones with poor performance will be discarded based on the prediction values of multiple traits; iv) Reduced duration of selection cycle from 5 to 3 years; v) Increased accuracy of performance evaluation in PYT and AYT by integrating genotypic data; vi) Available and accumulated genotypic and phenotypic data of breeding populations; vii) Increased capacity of breeding program and enhanced collaboration with national breeding programs (Figure 3).

From the crosses we made in the 2019-2020 pollination season, we selected 45 progenitors based on their performance in the cassava database at CIAT and their popularity in the crossing nurseries. In total, 516 seeds from these 45 progenitors were selected based on their pedigree were selected and planted as the training population.

Work Plan The training population will be quickly propagated from one seedling to 4-5 plants in the green house at CIAT. Before the plants are transplanted to the field for stem cutting increase in August 2020, we will collect tissues for genotyping. In May 2021, yield trials will be established

for phenotypic data collection at the north coast. We have planted the seeds in the green house in May. All the activities will be at CIAT in 2020, and COVID-19 has little impact on our activities.

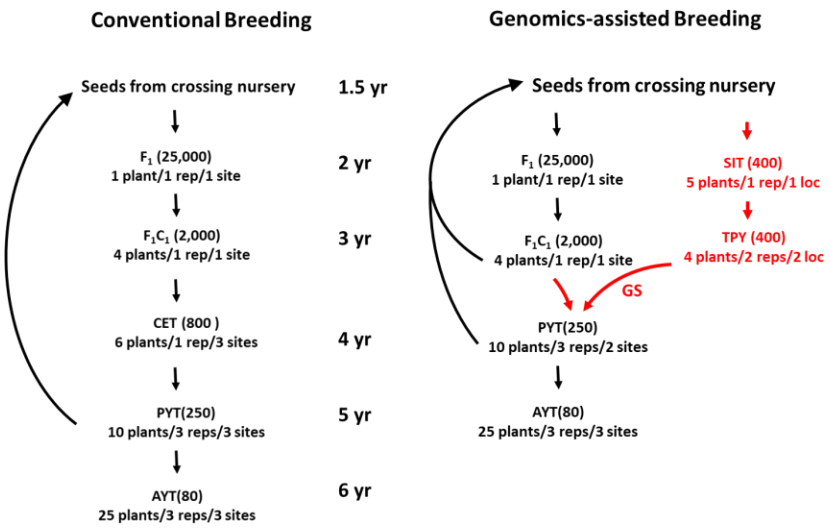

Figure 1. The genomic selection-based breeding scheme implemented at CIAT. The training population was selected from the breeding population based the pedigree. Quick clonal propogation is performed in green house to obtain 4-5 plantlet from one seedling. The plantlets will be transplanted into the field for stem cutting increase (or seed increase). In the Spring of 2021, yield trials with two replications will be established at two locations to collect phenotypic data, including plant type, dry matter, yield, and disease resistance. Simultinously, the breeding population will be planted in the field in 2020, and based on their performance, the population will be dramatically reduced from 25,000 to 2,000 clones. These 2,000 clones will be generated and planted for seed increase in 2021. The selected clones based on the predicted value will be planted into preliminary yield trials for variety development, and also planted in crossing nurseries as progenitors to produce seeds for the next cycle of selection. CET, Clonal Evaluation Trial; PYT, Preliminary Yield Trial; AYT, Advanced Yield Trial; SIT, Seed Increase Trial; TPY, Training Population Trial.

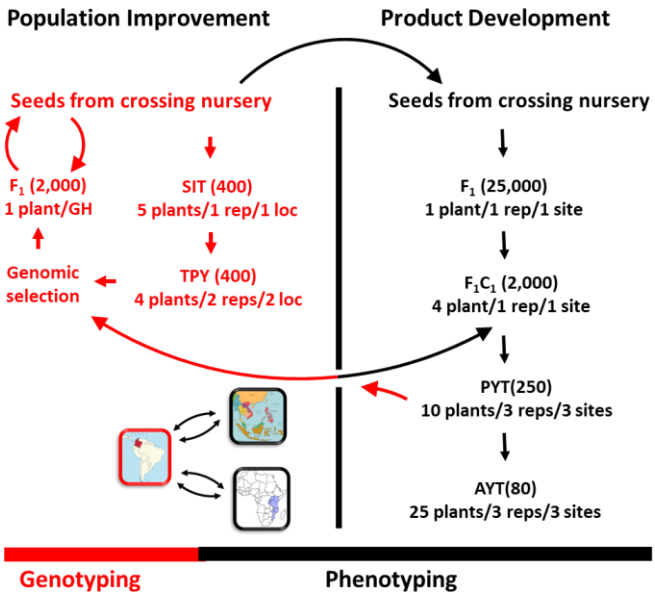

Figure 2. Genome selection facilitate moving CGIAR breeding programs "upstream" as providers of elite parents with high breeding values, and adapted progeny to NARS. The seeds of the training population can be easily shared with NARS collaborators. The training population will be evaluated in NARS environments. NARS-specific prediction models will be developed, and the predicted value of the breeding population will show their performance in NARS environments. The selections will either be shared with NARS or be crossed to produce seeds for sharing with NARS.

Breeding Mileston: Flowering: **Increased flowering and seed set protocols identified and tested resulting in increased cassava crossing efficiency while maintaining optimal plant types**

Year 2 targets: Lamp systems installed at 3 locations. 6 trials ongoing, 2 crossing nurseries piloting. 2 workshop events, 1 revised document.

Summary Report We met the target. Extended photoperiod conditition (EPC) was applied to all breeding progenitors at CIAT. Pruning and plant growth regulators are under test using breeding progenitors. One workshop was held at CIAT to discuss flower inducing among RTB crop breeders. Two manuscripts prepared and submitted to Frontiers in Plant Science

Detailed Report Generating seeds for breeding populations is the key stage for cassava breeding. The ability to make the designed crosses will increase the genetic diversity of the breeding population ($\boldsymbol{\sigma_A}$), and the ability to shorten the crossing season will reduce the duration of a breeding cycle ($\boldsymbol{L}$). The improvement of these two components will dramatically increase the

genetic gain of the breeding program. Thus, we spent effort to develop and implement the flower inducing technology in cassava breeding.

Cassava flower inducing technology including photoperiod extension, pruning and plant growth regulators has been tested at CIAT for several years. EPC has been proven to reduce the number of days required for the first branch at least six months (in genotypes with erect plant architecture) in Palmira. Pruning young branches prevents the abortion of the first branch inflorescences, and the simultaneous BA application dramatically increase the number of female flowers and provide the potential of large amount of seeds very early in the season. Two peer-reviewed papers about red light and prunning and BA were submitted for peer review. The video about pruning were developed and uploaded to Youtube, which are publicly available. Moreover, a workshop was organized at CIAT to discuss flower inducing technologies with RTB crop breeders in January 2020.

Three genotypes, GM971-2, CM4919-1 and SM3348-29 were used to test the flower inducing technology. One set of plants grew under dark-night (DNC) and in the other with extended photoperiod (EPC) using red light at night, which began the day of planting. There were five treatments implemented in each of the four genotypes (nested within each of these two photoperiod conditions): i) No pruning; ii) Pruning in the first branching event; iii) Pruning in the first branching event, combined with the application of benzyladenine (BA); iv) Pruning in the second branching event; and v) Pruning in the second branching event, combined with the application BA.

All genotypes respondes very well to EPC (e.g. flowered earlier). However, the impact was more noticeable in CM4919-1 and SM3348-29 (Figure 3). For genotype CM4919-1 under EPC, pruning (either in the first or second branching level) with the addition of BA was clearly advantageous, but the differences among the five treatments did not reach statistical significance. For both CM 4919-1 and SM 3348-29, pruning in the first branching event resulted in an early harvest of botanical seed that otherwise would not have been possible to obtain. Thus, flower inducing provided two benefits, reducing the duration of pollination season and increasing the possibility of generating seeds from designed crosses.

Different from CM4919-1 and SM3348-29, which have erect plant types without flowers under natural light, GM971-2 is a branching type, flowering normally under DNC (Figure 3). There was no clear flowering pattern that can be identified for this genotype. The best treatment was pruning in the second branching event without the application of BA, but the differences among the treatments did not reach statistical significance. For the branching type like GM971-2, breeders do not need to force changes in the flowering patterns since breeders can obtain seeds from

them easily and timely. However, an important lesson learned is that for plants that flower early (e.g. 2-3 months after planting) it is not productive to prune at the first branching event because at that age plants are too small.

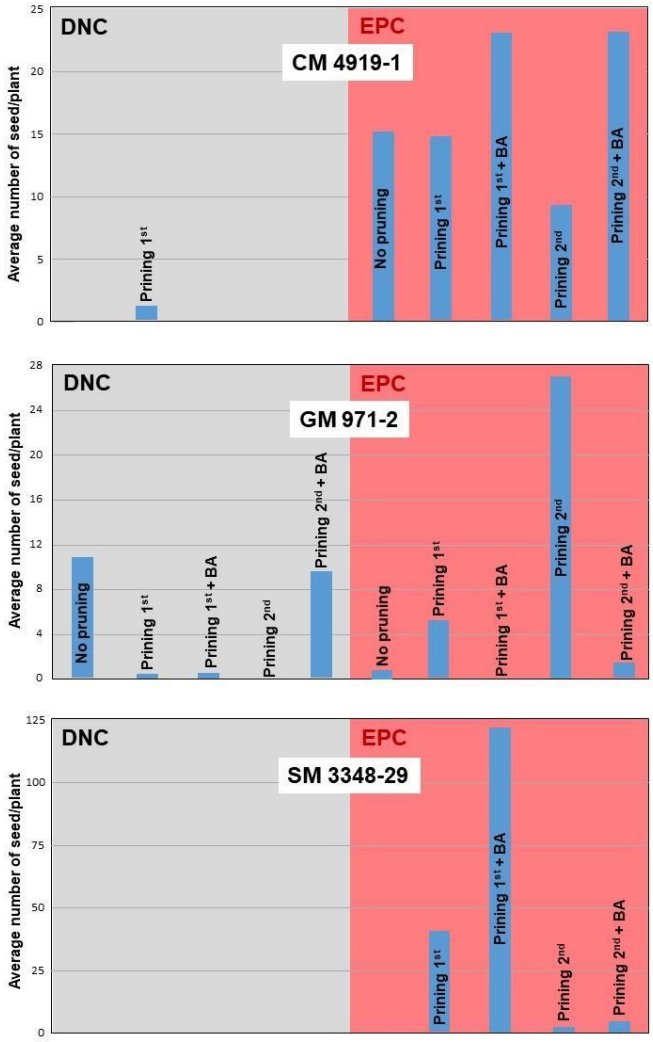

Figure 3. Average number of seed per plant produced under different treatments in three cassava genotypes. For each plot, the grey and reddish area presents results from plants growing under dark-night (DNC) and extended photoperiod (EPC) conditions, respectively. Within each photoperiod condition, five different treatments were evaluated (from left to right): no pruning, pruning in the first branch (without BA), pruning in the first branch (with BA), pruning in the second branch (without BA), and pruning in the second branch (with BA).

We also observed that pruning and applying BA promoted feminization of flowers, but for some genotype, there was a sharp increase in the number of hermaphrodite flowers (e.g. male flowers becoming hermaphrodite; Figure 4). Moreover, in many cases, what should be male became a female-only flowers. The feminization of flowers is a positive development and explains the unprecedented number of seeds per plant that could be obtained, for example, in SM3348-29. The occurrence of hermaphrodite flowers would facilitate self-pollinations and thus a wider utilization of inbreeding for the genetic enhancement of cassava. However, it also presents a new problem because, to guarantee crosses for the production of hybrid seeds, they would require emasculation. There are ongoing efforts to foster the feminization process (e.g. reduce the number of hermaphrodite flowers in favor of female-only flowers) through increased concentration of BA treatments.

Figure 4. Effect of pruning and application of plant growth regulators such as BA. The photograph on the left illustrates inflorescence at the first branching event from SM3348-29 after pruning and BA application. The flower within the square is hermaphrodite, whereas flowers

within circles are female only. The three photographs on the right show a typical male flower (top), a female flower with intermediate (middle) or full development (bottom) of anthers.

EPC was implemented on 116 progenitors used in the breeding program at CIAT (Figure 4). EPC dramatically reduded the height of the first branch from 104.8 cm under dark night to 78.5 cm, which indicated early flowering. Moreover, under extended photoperiod, all the clones had at least one branches. Using a large population, we verified EPC can induce branching or flowering and reduce the height of the first branch or promote early flowering.

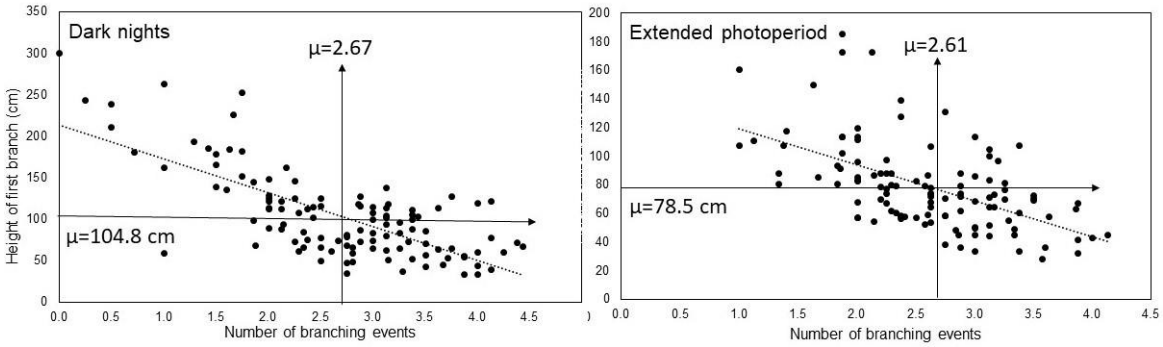

Figure 5. The effect of red light on number of branching events and height of the first branching. DNC, dark-night (DNC); EPC, extended photoperiod (EPC).

Work Plan After testing the flower inducing technology in several genotypes, we are going to implement the technology in breeding crossing nurseries. Red light (or EPC) will be implemented for all three polycrossing nurseries and one master paired crossing nursery. The response of 135 progenitors on red light at night, pruning, BA and STS will be observed. The effect of the concentration of plant growth regulators (BA and STS) on flower types will be tested using 10 genotypes. Crossing nurseries have been established at CIAT in May. COVID-19 has little impact on our activies.

Activities without matched milestones in Year 2, Explore heterosis in Cassava.

Summary Report. In total, 1147 plants from 23 selfing families were planted at CIAT. About 50 cloens will be selected for self-pollination to purge genetic load and cross-pollination to test GCA.

Detailed Report. We started exploring the heterosis in Cassava and made selfing of 23 clones, of which 20 clones have high dry matter and three have high beta-carotene. Even though cassava is a clonal propagation crop, we still started with selfing to explore heterosis. Compared with using conventional breeding material, selfing provided at least three advantages, 1) selfing is efficient to purge recessive deleterious mutations; 2) selfed clones show smaller within family

variation and larger among family variation, which facilitates determining GCA; 3) inbred or semi-inbreed progenitors will make trait introgression in cassava as efficient as that in corn and rice. In 2019 October, we planted 1147 seeds from 23 progenitors, and these plants were transplanted into the field in Palmira in January 2020 (Table 3). Selection will be made based on their vigor, plant type, and disease resistance. From each famlily, 1-3 clones will be selected self-pollination to purge genetic load and cross-pollination to test GCA.

Table 3. The S1 families planted in Palmira in Jan 2020.

cross	parent		num_plant	cross	parent		num_plant
AM1570	AM1253-6	beta-carotene	36	AM1608	SM3110-15	dry matter	50
AM1590	AM1451-4	beta-carotene	32	AM1609	SM3134-5	dry matter	47
AM1592	AM1572-22	beta-carotene	36	AM1612	SM3196-1	dry matter	47
AM1427	SM3150-17	dry matter	45	AM1618	HB60	dry matter	28
AM1597	GM579-13	dry matter	53	AM320	TAI8	dry matter	34
AM1598	GM957-11	dry matter	48	AM329	SM805-15	dry matter	36
AM1599	GM1067-28	dry matter	49	AM332	SM1411-5	dry matter	96
AM1600	GM1070-17	dry matter	47	AM405	SGB765-4	dry matter	43
AM1602	GM1406-12	dry matter	52	AM578	SM2629-36	dry matter	44
AM1603	GM1484-8	dry matter	47	AM583	SM2792-31	dry matter	40
AM1605	SM2828-28	dry matter	90	AM889	GM273-57	dry matter	94
AM1607	SM3060-34	dry matter	53				

Work plan. An inbred or semi-inbred based hybrid breeding scheme was proposed (Figure 6). Compared with corn, the clonal propagation is an advantage for cassava. No hybrid seed production system is required. To make the most of the clonal propagation, in the proposed scheme below, we combine selfing, GCA test and variety development in one breeding scheme. For example in 2021-2022, we are going to self-pollinate S1 clones and also cross-pollinate S1 clones (polycross will be used to reduce labor cost; parentage analysis will be used to determine the male parents). In 2022-2023, we are going to plant S2 in the field for selection based on their vigor, plant type and disease resistance. The progeny from cross-pollination among S1s will go through F1 and CET stage in two years, 2021-2023. GCA will be estimated at CET stage and best clones will be advanced for variety development. Based on the GCA of S1 clones, certain S1 families (S2 plants) will be select for further self- and cross-pollination. On the other hand, based on the GCA, the S1s will be grouped into two heterotic groups. Reciprocal recurrent selection and selfing will be used to improve individual heterotic groups, and varieties will also be developed from crosses between heterotic groups. All the activities are in Palmira at CIAT in 2020. Our team

members are able to plant, manage and harvest trials. COVID-19 has little impact on our activities.

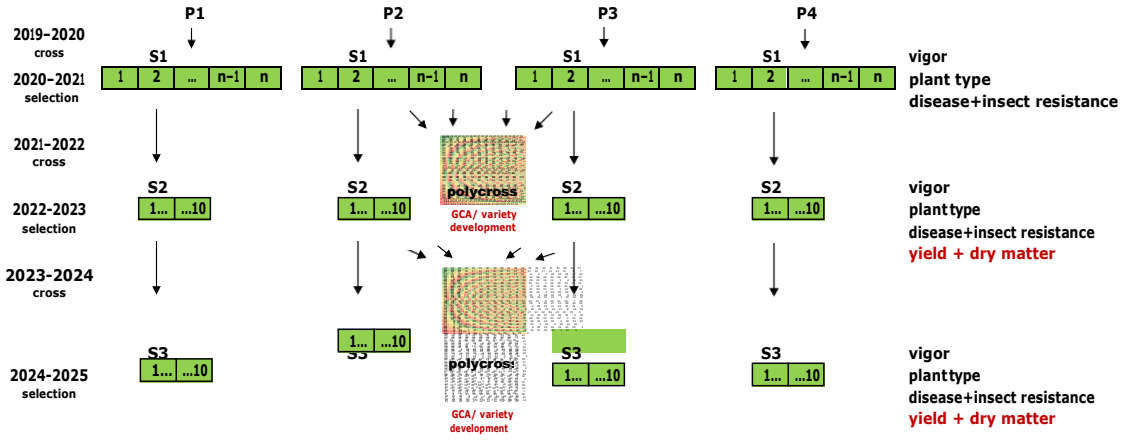

Figure 6. Inbred or semi-inbred based hybrid breeding scheme in cassava. The main purpose of this breeding scheme is to identify the heterotic groups at the S1, S2 or S3 stage. Once heterotic groups were identified, reciprocal recurrent selection and selfing will be used to purge genetic load and increase the GCA of individual groups. Taking the advantages of clonal propogation of cassava, we combine selfing (to purge genetic load), testing GCA (to identify heterotic groups), and developing superior varieties into one breeding scheme.

NEXTGEN CASSAVA

- **Capacity Building:** List any researchers visiting your organization, visits your organization staff have undertaken, or training courses attended under NextGen Cassava in this reporting period.

Date	*Visitor/Affiliation*	*Destination/Host*	*Purpose of Travel*
April 20 – May 9, 2019	13 Ph.D and 12 M.Sc candidates from 10 different countries [D.R. Congo (1), Ethiopia (1), Ghana (3), Kenya (6), Liberia (1), Mozambique (1), Nigeria (1) Uganda (14), Tanzania (5) and Zambia (1)	MARCCI	Give lectures and review research proposals

Research the research proposal from the following students at MaRCCI were reviewed (face to face):

1. Ano Chukwuka (M.Sc. NRCRI, Nigeria). Cassava	13. Said Abdallah (M.Sc. from Tanzania), Rice
2. Eyoo Oscar (M.Sc. Uganda). Cassava	14. Eiiet Emmanuel (M.Sc. from Uganda), Finger millet
3. T. Arwailayah Freeman (Ph.D. Liberia). Cassava	15. John Kutuka (M.Sc. Kenya), Maize
4. Babirye Fatumah Namakula (M.Sc. Uganda). Cassava	16. Artur Anacio Fernando (M.Sc. Mozambique). Beans
5. Manze Francis (M.Sc. Uganda, NextGen). Cassava	17. Hellen Gitonga (Ph.D. Kenya) Cowpea
6. F. Bura Gwandu (M.Sc. Tanzania NextGen). Cassava	18. Perpetua Arusey (Ph.D. Kenya) Cowpea
7. K. Leonard Sichalwe (Ph.D. Tanzania NextGen). Cassava	19. Mikidadi Abubakar (Ph.D. Tanzania). Cassava
8. Imvikia Dorothy (M.Sc Uganda). Sweetpotato	20. Dejene Kebede Astatke (Ph.D. Ethiopia). Sorghum
9. Akech Winnyfred (M.Sc Uganda). Sweetpotato	21. Danielle Essandoh (M.Sc, Ghana) Groundnut
10. Immaculate Mugisa (Ph.D. Uganda). Sweetpotato	22. Ojok Samson (M.Sc. Uganda). Rice
11. Cheelo Pride Chinya (Ph.D. Zambia). Beans	23. Kesiime Eunice (Ph.D. from Uganda) Bean
12. Sheila Limo (M.Sc. Kenya) Cowpea	

- **Workshops:** List any NextGen findings and accomplishments presented at relevant workshops, meetings or conferences. Add rows as needed.

Title	*Author(s)/Presenter(s)*	*Conference/Meeting, Dates*	*Format*
Flower inducing technology in Cassava	Hernan Ceballos	Induction of Flowering Workshop; Jan 23	Workshop

Cassava breeding for Impact at CIAT	Xiaofei Zhang	Induction of Flowering Workshop; Jan 23	Workshop

- **Students:** If your institute has MSc or PhD students funded through NextGen, give a brief update on where they are currently in their studies.

Name	*Institution*	*Nationality*	*Gender*	*Research title*	*Status*
Lizzeth Marcela Pineda	Universidad Nacional de Colombia	Colombia	F	Understand the effect of red light, pruning and growth regulation on cassava flowering	***On-going***
Erika Barinas	Universidad Nacional de Colombia	Colombia	F	Develop methods to maintain the pollen activity for medium- or long-term storage	***On-going***

Marcela Pineda's summary

Making crosses between progenitors is the first stage of cassava breeding. Flower inducing will increase the cross efficiency and shorten the duration of the pollination season. Three components of the flower inducing technology was tested and implemented in Palmira at CIAT to obtain and increase the number of seed and require less time:

1). Flowering is closely related to the production of branches; therefore, the genotypes of erect plants do not have inflorescences. The implementation of red light was carried out in plants in the field. In some erect-plant genotypes, the development of the branches was promoted and in the branched genotypes, the time of appearance of the branches was reduced

2). The crosses start from approximately 6 months (according to each genotype) due to in the first branches the plants abort the inflorescences. Pruning in the first branches was implemented to stimulate the growth of inflorescences, achieving full development of the inflorescences until fruit is obtained.

3). In each inflorescence there is a lower production of female flowers than of male flowers. The use of benzyladenine was implemented to change male flowers into female flowers. It became some genotypes increased the number of female and hermaphrodite flowers and therefore seeds.

The combination of these treatments resulted in a decrease in days to obtain viable flowers for seed development, in addition to increasing the number of seeds per plant in some genotypes. In

the following experiments, in pruned plants, different benzyladenine concentrations will be evaluated to promote total flower change in the genotypes that generated hermaphrodite flowers in previous trials, in addition to the use of silver thiosulfate (STS) to promote the growth and development of inflorescences. The application of STS and BA can also be carried out on plants without pruning to evaluate the effect of these on seed yield.

Erika Barinas' summary

The desiccation of cassava pollen would be a great step towards developing conservation processes, and therefore achieving important advances in the crossing of genotypes that bloom at different times or in different regions.

Pollen desiccation and rehydration trials were conducted to assess viability. Female flowers were pollinated with pollen desiccated for 1, 2 and 3 hours and then rehydrated for 1 hour. Pollinations were compared with two controls, the first with conventional pollination (with untreated pollen) and the second with rehydrated flowers (without desiccation), after 24 hours. The pollinated flowers were collected and fixed to later evaluate germination in vivo to dissect the flowers and observe the development of pollen tubes in the ovules, using a fluorescence microscope.

There was growth of pollen tubes in flowers pollinated with desiccated pollen and in flowers pollinated with pollen desiccated and subsequently hydrated. Flowers pollinated with desiccated pollen and subsequently hydrated, showed greater growth of pollen tubes compared to flowers pollinated with desiccated pollen only. We are going to carry out new tests for drying and rehydrating pollens to standardize an adequate methodology.

- **Feedback to the Foundation (optional)**: Provide one way the foundation has successfully enabled your work so far, and one way the foundation can improve.

Appreciate the great support in genomic selection. We, cassava program at CIAT, are excited to implement the genomic selection-based breeding scheme. We believe that genomic selection opens the door for CGIAR to breed for national programs, by sending seeds of the training populations to partners and develop GS models specific for the TPE of NARS. CGIAR program will be positioned "upstream" and can provide elite parents/populations to NARS adapting their TPE.

Heterosis and hybrid breeding has been successfully used in seed crops. Cassava has high genetic load and shows high inbreeding depression, but breeders not little about the heterosis and general combining ability (GCA) in cassava. Both CIAT and IITA has started exploring GCA based hybrid breeding in Cassava. Besides be focused on product profiles and produce development, we hope CIAT and IITA can work together and have better support to explore the heterosis and GCA in cassava.