Ground Penetrating Radar (GPR)Project: Below-ground cassava root phenotyping

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Introduction

- Cassava is a vital dietary food source for people globally. (FAO, 2013; Droppelmann K. et. el.,2018)

- With the ability to store mature edible roots in ground for roughly three years, cassava is a principal food security source in tropical regions. (Saranraj, P., et al. 2019)

- The crop is also utilized for animal feed and industrial raw materials including starch and dried chips. (Ugwu B. et. el., 1996; Ezedinma Cl., et el., 2007; Odunze DI., et el., 2019).

- Breeders can focus on high fresh root yield, dry matter content, and suitable plant architectures for crop improvement that would meet man and industrial needs.

- Cassava root system is underground and cannot be phenotyped as accurately and rapidly as canopies

- A new rapid and non-destructive, novel method for root phenotyping is necessary

Project Goal

- Temporal Root Scanning in Cassava using Ground Penetrating Radar (GPR)

- Improve trait selection by adapting a technology from geophysics called GPR to produce three-dimensional quantifiable images of cassava roots non-destructively

- Using GPR, root bulking detection can be performed through temporal root mass imaging

- Select cassava varieties that increase yields by 25-50% by detecting early-maturing root from existing high yielding genotypes

System Start to Present
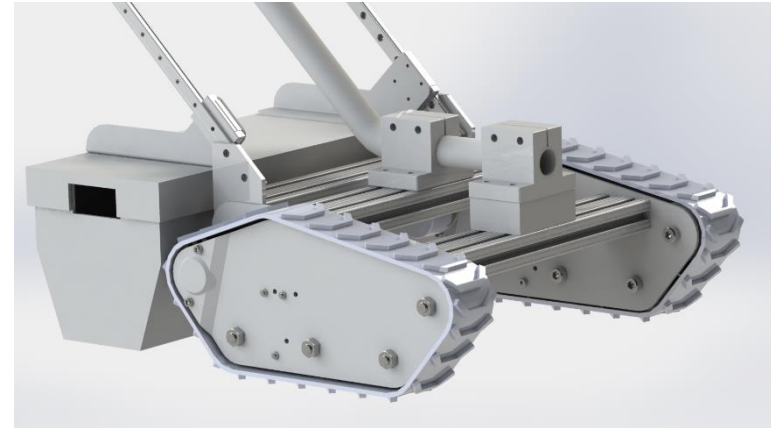
Data acquisition events – 2020

- We had a visit of our USA partner on GPR project from IDS GeoRadar company, Colorado, North America.

- The two-man collaborator arrived IITA on February 24, 2020 and departed for USA on March 10, 2020.

- Alfredo Delgado, a team lead, briefed IITA team on his plan for the scanning operation during the visit. His colleague was Carl McIntyre.

- We had the root scanning - data acquisition operations in Ibadan and Ikenne.

- We scanned cassava roots in IITA Ibadan: AYT (EE 23 and EC 10); Seedling Nursery (ES 21) trials

- DCT, UYT and PYT genetic stock trials were scanned in Ikenne

- Prior to scanning operation, We collected pre scanning data such as plot row length measurement and cassava plants stand reference point.

- We did post scanning operations: harvesting and collection of harvest data.

Data Acquisition Events - 2020
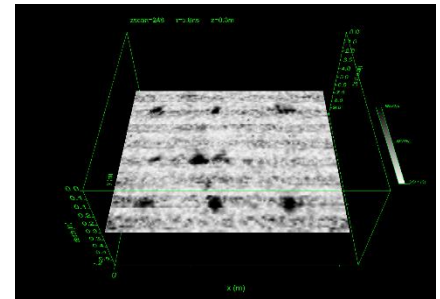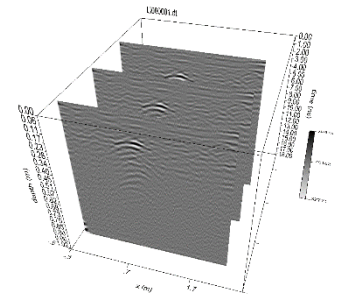
GPR trial establishment for 2021 data acquisition

- We had a meeting on design and establishment specifically for GPR trials purpose.

- The trial were sited in 2 location in Ibadan (2 sites) and Ikenne (1 site)

- Two contrasting soil types (Sandy and Clayey) represented each site in Ibadan.

- We agreed to use 5 genotypes and a vacant plot as the sixth treatment

- The layout was AYT format (5.6m x 4m = 22.4m2) tagged AYT6
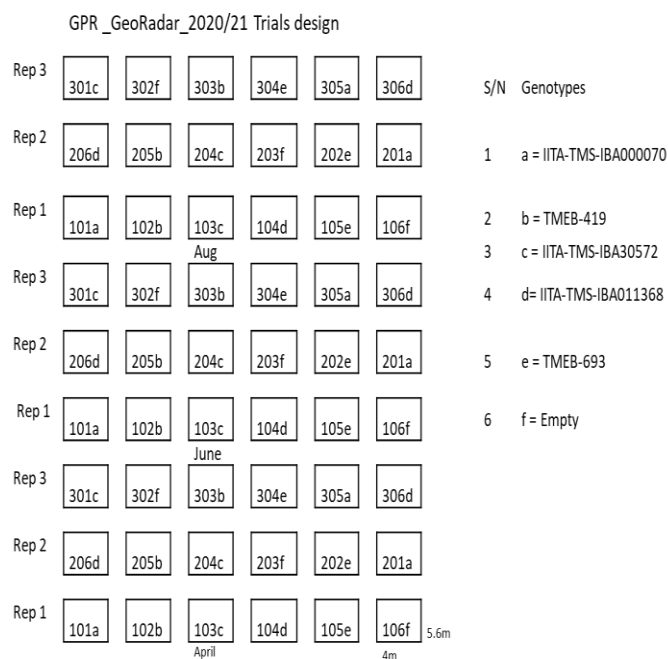
GPR trial Establishment for 2021 data acquisition

GPR _GeoRadar_2020/21 Trials design

Rep 3	301c	302f	303b	304e	305a	306d
Rep 2	206d	205b	204c	203f	202e	201a
Rep 1	101a	102b	103c	104d	105e	106f

Aug

Rep 3	301c	302f	303b	304e	305a	306d
Rep 2	206d	205b	204c	203f	202e	201a
Rep 1	101a	102b	103c	104d	105e	106f

June

Rep 3	301c	302f	303b	304e	305a	306d
Rep 2	206d	205b	204c	203f	202e	201a
Rep 1	101a	102b	103c	104d	105e	106f

April   5.6m   4m

S/N	Genotypes
1	a = IITA-TMS-IBA000070
2	b = TMEB-419
3	c = IITA-TMS-IBA30572
4	d= IITA-TMS-IBA011368
5	e = TMEB-693
6	f = Empty

Table1: Trials Establishment for GPR planting date and Scanning root age

Planting date	Age _March2021	Age_April2021
April 2020	11MAP	12MAP
June 2020	9MAP	10MAP
August 2020	7MAP	8MAP
October 2020	5MAP	6MAP

Table2: Trial Establishment for root scanning at harvest (10 – 12 MAP)

Planting date	10 MAP	12MAP
May 2020	March2021	May2021
September 2020	July2021	September2021
November 2020	September2021	November2021

Report on GPR Online Training Meetings 1: Data processing and imagery analysis

- The Online virtual training meeting was organized to acquaint and guide IITA team into procedure for GPR-slice data analysis for root imagery and pixel counts.

- The introductory training was on basic radargram signal processes and 2D/3D imaging processes in GPR-SLICE from raw data to the 3D volume imagery. This was anchored by Dean Goodman.

- This was a general training on basic principle and procedure used by geophysics to detect underground objects such as metals, underground water pipes et cetera. The meeting was conducted for IITA and CIAT teams held on 15 July 2020

- Agricultural application with GPR-slice training was anchored by Alfredo Delgado. The meeting was on 3 September 2020.

- The imagery processes and pixel count analysis training not yet concluded. We hope to continue this in 2021

GPR-slice analyzed root image
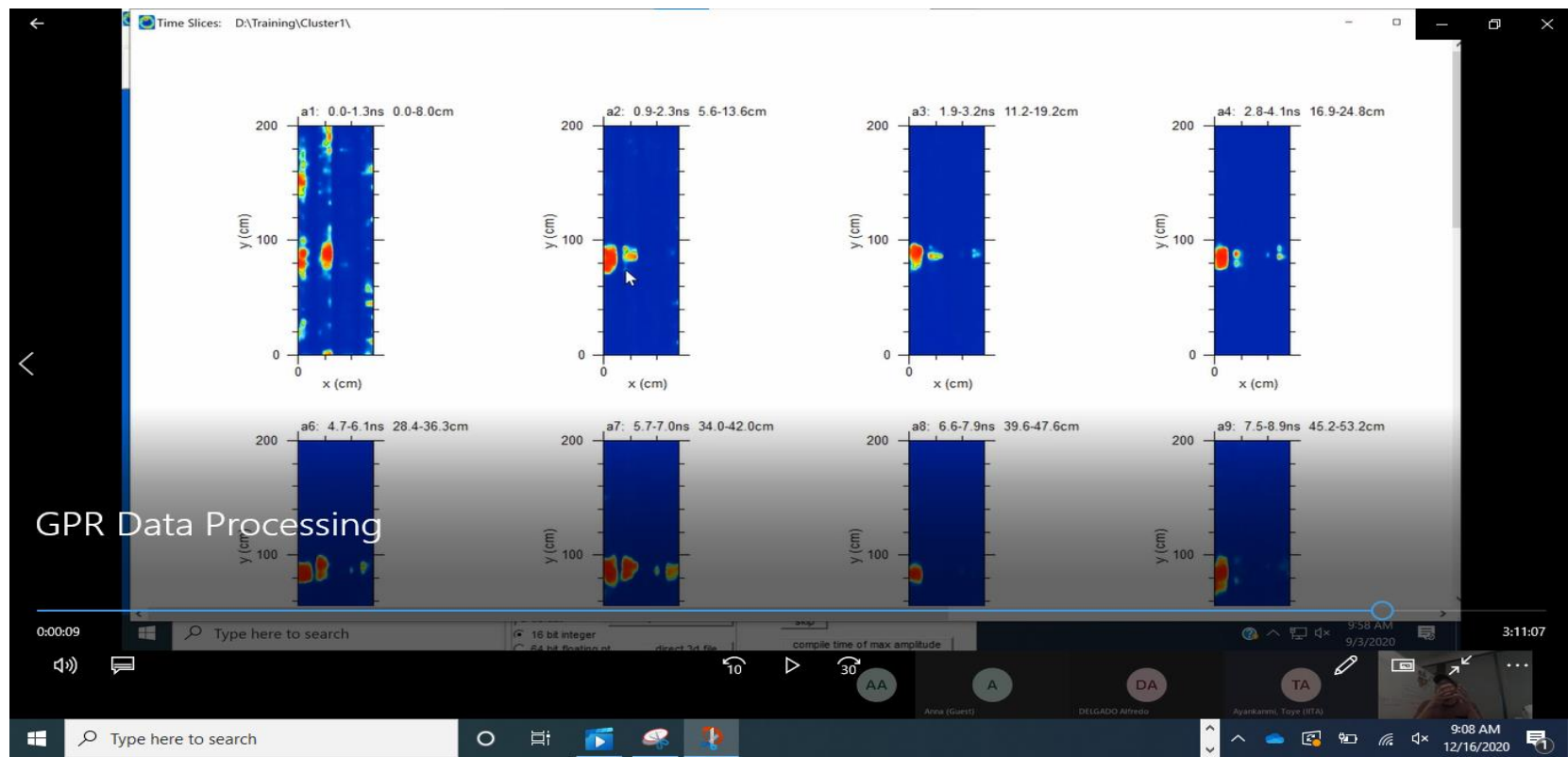
Report on GPR Online Training Meetings 2:
Man-Machine interface (MMI) acquisition software discussions

- We had 6 weekly meetings between October 5 to November 18, 2020

- The meetings focused on user inputs interface software development for data acquisition in 2021.

- We discussed some of the features and components we would like to have in new data acquisition software.

- We emphasized the need to have a simple and easy to use radar.

- Ability to pre-load field layout and other settings into software

- Steady Hardware/Cart to minimize wobbling on the field

- Desired durable battery on radar machine for data collection on the field

GPR Online Training Meetings Activities 2 contd.: Man-Machine interface (MMI) acquisition software discussions

- Requested for ability for note taking during acquisition on the software.

- Enable camera for picture / video integration

- Ability for the equipment to have data quality check

- Needed hardware/tablet with strong screen protector and brightness.

- Ability to capture root depth real time and provide information for harvesting.

- Possible GPS integrated software within the acquisition software.

- Collection of GPS and GPR data simultaneously.

- The Cart is expected to be light to push and handled by the user.

MMI Possible End User View
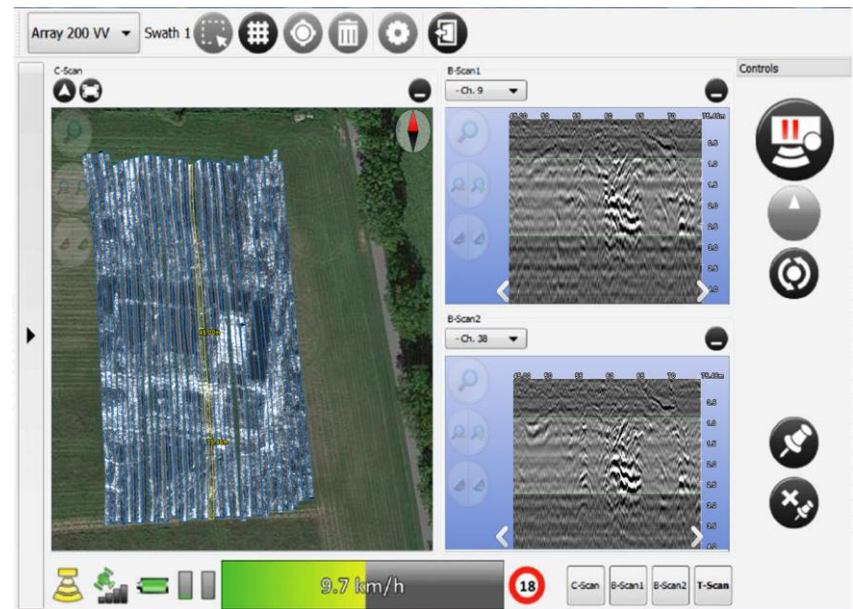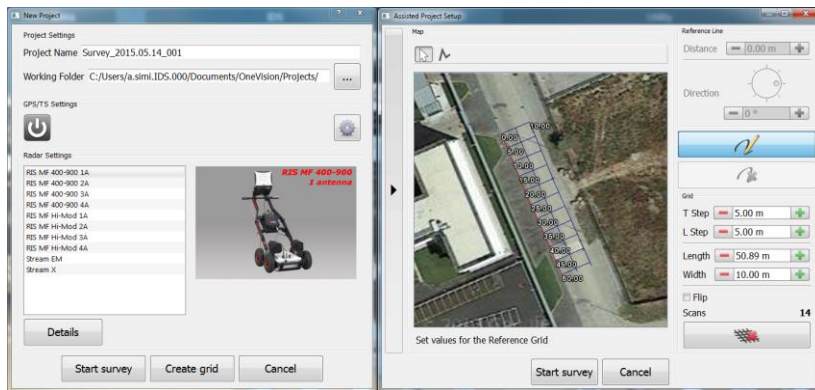
Proposed plan for extensive GPR data acquisition operations in 2021

- Scaling up of GPR data acquisition with the NextGen, Harvest plus projects and student trials especially Simon Peter (NRCRI) and Segun Badewa (IITA) in 2021.

- This year, we will be obtaining information/data on Radar performance on variable soil types, soil moisture content and agroecology.

- More training on data analysis/imagery, pixel counts, and its interpretation

Table3: Proposed Cassava Breeding Trials' Projects for GPR data acquisition in 2021

No	Trial Name	Trial Type	Field	Number of Replication	Number of plots/Rep	Total Plots	Stands /Plot	Spacing	Field_Size (ha)	Plot_Size (M)	Location	Date of Planting	Expected Date of Harvesting
1	20.GS.C5.CE.820.IB	CET	ES11	1	820	820	7	1M X 0.5	0.574	1M X3.5M	IBADAN	21-Nov-20	21-Nov-21
2	20.GS.C4C.PYT.90.IB	PYT	B12	2	90	180	10	1M x 0.8	0.18	4M X 2M	IBADAN	29-Sep-20	29-Sep-21
3	20.Hawaii.PYT.54.AG	PYT	AGO-OWU	2	54	108	10	1M x 0.8	0.0108	2M X 4M	AGO-OWU	12-Jul-20	12-Jul-21
4	20.Hawaii.PYT.54.IK	PYT	IKENNE	2	60	120	10	1M x 0.8	0.012	2M X 4M	IKENNE	12-Jul-20	12-Jul-21
5	20NCRPMK	NCRP	MOKWA	2	18	36	42	1M x 0.8	0.01512	6M X5.6M	MOKWA	4-Aug-20	4-Aug-21
6	20.CASS.PYT52.IK	PYT	IKENNE	2	52	104	36	1M x 0.8	0.3744	6M X 5.6M	IKENNE	12-Jul-20	12-Jul-21
7	20.GS.C3.C4.UYT.25.ON	UYT	ONNE	2	25	50	42	1M x 0.8	0.021	6M X 5.6M	ONNE	5-Sep-20	5-Sep-21
8	20.GS.C1.C2.C3.UYT.30.IB	UYT	ES12	2	30	60	42	1M x 0.8	0.0252	6M X 5.6M	IBADAN	3-Jul-20	3-Jul-21
9	20.GS.C1.C2.C3.UYT.30.MK	UYT	MOKWA	3	30	90	42	1M x 0.8	0.0378	6M X 5.6M	MOKWA	3-Jul-20	3-Jul-21
10	20.GS.C2.setA.UYT36.IB	UYT	D18	2	36	72	20	1M x 0.8	0.0144	2M X 4M	IBADAN	15-May-20	15-May-21
11	20NCRP12yrtAB	NCRP	ABUJA	3	12	36	35	1M x 0.8	0.0126	5.6MX5M	ABUJA	23-Jul-20	23-Jul-21
12	20NCRP12YRTAG	NCRP	AGO-OWU	3	12	36	35	1M x 0.8	0.0126	5.6MX5M	AGO-OWU	7-Dec-20	7-Dec-21
13	20AYT30HighTCAG	AYT	AGO-OWU	3	30	90	28	1M x 0.8	0.0252	5.6MX4M	AGO-OWU	10-Aug-20	10-Aug-21
14	20AYT25HighTCIB	AYT	B1	3	25	75	28	1M x 0.8	0.021	5.6MX4M	IBADAN	14-Aug-20	14-Aug-21
15	20AYT28HighTCIB	AYT	B1	3	28	84	28	1M x 0.8	0.02352	5.6MX4M	IBADAN	4-Sep-20	4-Sep-21
16	20AYT30HighTCIB	AYT	B1	3	30	90	28	1M x 0.8	0.0252	5.6MX4M	IBADAN	10-Aug-20	10-Aug-21
17	20aytT35highTCIB	AYT	B1	3	35	105	28	1M x 0.8	0.0294	5.6MX4M	IBADAN	27-Aug-20	27-Aug-21
18	20PYT24HighTCIB	PYT	BS23	2	24	48	5	1M x 0.8	0.0024	4MX1M	IBADAN	4-Jun-20	4-Jun-21
19	20pyt26yrthighDMIB	PYT	BS24	2	26	52	5	1M x 0.8	0.0026	4MX1M	IBADAN	09-Apr-20	09-Apr-21
20	20pyt28HighTCIB	PYT	BS24	2	28	56	5	1M x 0.8	0.0028	4MX1M	IBADAN	17-Apr-20	17-Apr-21
21	20pyt32HighTCIB	PYT	BS24	2	32	64	5	1M x 0.8	0.0032	4MX1M	IBADAN	17-Apr-20	17-Apr-21
22	20PYT34HighTCIB	PYT	BS23	2	34	68	5	1M x 0.8	0.0034	4MX1M	IBADAN	06-Apr-20	06-Apr-21
23	20pyt42yrthighYldIB	PYT	BS24	2	42	84	5	1M x 0.8	0.0042	4MX1M	IBADAN	15-May-20	15-May-21
24	20pyt46HighTCIB	PYT	BS23	2	46	92	5	1M x 0.8	0.0046	4MX1M	IBADAN	15-May-20	15-May-21
25	20pyt48HighTCIB	PYT	BS23	2	48	96	5	1M x 0.8	0.0048	4MX1M	IBADAN	15-May-20	15-May-21
26	20pyt54highTCIB	PYT	B1	2	54	108	10	1M x 0.8	0.0108	8MX1M	IBADAN	24-Sep-20	24-Sep-21
27	20pyt64highTC2IB	PYT	B1	2	64	128	10	1M x 0.8	0.0128	4MX1M	IBADAN	24-Sep-20	24-Sep-21
28	20pyt64HighTCIB	PYT	BS24	2	64	128	5	1M x 0.8	0.0064	4MX1M	IBADAN	04-Sep-20	04-Sep-21
29	20.Harvestplus.Batch2.SN.IB	SN	B11	1	18368	18368	1	1M x 0.25	0.18368	20MX1M	IBADAN	09-Aug-20	09-Aug-21
30	20.Harvestplus.SN.IB	SN	ES12	1	14403	14403	1	1M x 0.25	0.14403	20MX1M	IBADAN	24-Jun-20	24-Jun-21
31	20NCRP12yrtIK	NCRP	IKENNE	3	12	36	35	1M x 0.8	0.0126	5.6MX5M	IKENNE	09-Jul-20	09-Jul-21
32	20AYT28HighTCMK	AYT	MOKWA	3	28	74	28	1M x 0.8	0.02072	5.6MX4M	MOKWA	3-Sep-20	3-Sep-21
33	20NCRP12yrtMK	NCRP	MOKWA	3	12	36	35	1M x 0.8	0.0126	5.6MX5M	MOKWA	9-Jul-2020	9-Jul-2021
34	20NCRP12yrtZA	NCRP	ZARIA	3	12	36	35	1M x 0.8	0.0126	5.6MX5M	ZARIA	25-Jul-20	25-Jul-21
35	20pyt220GPRikenne (Simon Peter)	PYT	IKENNE	2	220	440	5	1m x 0.8m	0.022	2m x 4m	IKENNE	2-Jun-20	2-Jun-21
36	20pyt220GPRikenne (Simon Peter)	PYT	UMUDIKE	2	220	440	5	1m x 0.8m	0.022	2m x 4m	UMUDIKE	28-Apr-20	28-Apr-21
37	20PYT42HTCbulkIB (Segun Badewa)	PYT	A1E	2	126	252	5	1M x 0.8	0.0126	4MX1M	IBADAN	06-May-20	06-May-21