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Cassava Weed Management Project at Work

2016 Progress Report

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2016 Progress Report

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Content

Acronyms

ACAI	African Cassava Agronomy Initiative
ADP	Agricultural Development Program
AEZ	Agroecological zone
ALS	Acetolactate synthase
ASUT	Akwa Ibom State University of Technology, Abak
BASICS	Building an Economically Sustainable Integrated Cassava Seed System
CDO	Capacity Development Office
DAT	Days after pre-emergence herbicide treatment
EDADP	Edo State Agricultural Development Program
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
FMARD	Federal Ministry of Agriculture and Rural Development
FUNAAB	Federal University of Agriculture, Abeokuta
IFAD	International Fund for Agricultural Development
JQRM	Joint Quarterly Review Meetings
KAP	Knowledge, Attitude and Practices
JDPM	Justice Development and Peace Movement
LGA	Local Government Area
M&E	Monitoring and Evaluation
MoU	Memorandum of Understanding
NAFDAC	National Agency for Food and Drug Administration and Control
NCGA	Nigeria Cassava Growers Association
NCRI	National Cereals Research Institute
NESREA	National Environmental Standards and Regulations Enforcement Agency
NGOs	Non-Governmental Organizations
NRCRI	National Root Crops Research Institute
PAO	Project Administration Office
PC	Project Coordinator
PI	Principal Investigator
PM	Project Management
RCBD	Randomized Complete Block Design
S&Sp	Site and Species specific
SABs	South African Bureau of Standards
SAS	Statistical Analysis Software
SC	Steering Committee
SSPs	Spray Service Providers
SON	Standards Organization of Nigeria
SWOT	Strength, Weakness, Opportunities and Threats
TNA	Training Needs Assessment
UAM	University of Agriculture, Makurdi
WAP	Weeks After Planting
WAT	Weeks After Treatment
WSC	Weed Science Center

Background

The Cassava Weed Management Project (Sustainable Weed Management Technologies for Cassava Systems in Nigeria) is a 5-year project designed in response to the devastating effects of weeds on cassava and farm families in Nigeria. The project, which started in late 2013 aims to minimize the drudgery of hand weeding by women and children, and increase cassava productivity using improved and integrated approaches to weed management that reduce labour requirements and enhance the productivity of smallholders' cassava farms. This will be achieved by supporting smallholder farmers to use modern, relevant, and appropriate cassava weed management technologies suitable for sustainable intensification in major agro-ecological and socio-economic conditions of Nigeria.

This project builds on existing and new partnerships that include cassava producer associations, agro-dealers, chemical companies, the University of Agriculture at Makurdi; National Root Crops Research Institute(NRCRI), Umudike; the Federal University of Agriculture, Abeokuta (FUNAAB); the Federal Ministry of Agriculture and Rural Development; National Agency for Food and Drug Administration and Control (NAFDAC); Standards Organization of Nigeria; National Environmental Standards and Regulations Enforcement Agency (NESREA); Agricultural Development Programs and other extension service providers. Over the five-year period, the project will provide knowledge to 125,000 Nigerian cassava farm families with better crop and weed management know-how/options.

Since its commencement in 2013/2014, the Cassava Weed Management Project has made some gains. This progress is captured in this report in the context of the project's Results Framework under the following Objectives:

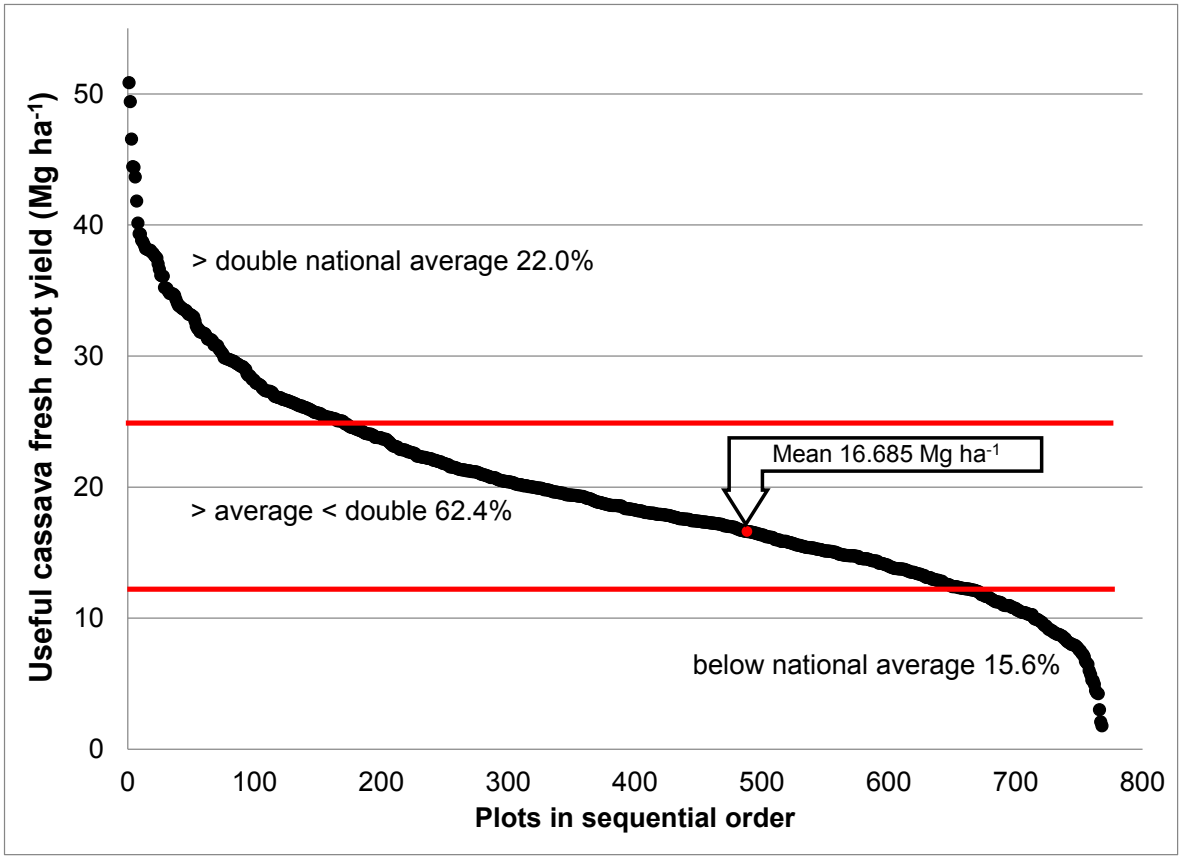
Objective 1

This Objective seeks to develop appropriate agronomic practices that increase cassava productivity, and reduce losses from weed competition and drudgery for women and children. To achieve this Objective, the following outputs were recorded from the milestones below:

Key Milestone: Key mile stone: All agronomy trials on cassava variety x density x tillage x intercrop x fertilizer trials conducted and harvested.

IITA and partners have conducted the agronomy trials and all trials were analyzed individually as well as across the sites by season. Major results across sites are as follows: for first season plantings site differences were pronounced and average yields were generally higher than the national average with one site exceeding 25 Mg ha^{-1} (double the national average); the highest yields were attained by ridging in sole cassava using TME 419. Fertilizer application was significant yet had a lower yield effect than all other factors; highest yields were attained with the highest plant densities at harvest indicating that the cassava density should be increased to at least 12500 ha^{-1} to maximize yield. The yield distribution across sites was 13.75% below the national average and 29.8% above the double national average, with an overall mean of 21.2 Mg ha^{-1}, indicating that simple agronomic measures offer ample opportunity to increase cassava yields. In the second season, two sites exceeded 20 Mg ha^{-1} average fresh root yield while one site remained below the national average. Fertilizer application had the strongest effect on root yields, followed by sole cassava and ridging. As in the previous year, the varietal advantage of TME 419 did not show in the second season planting. The importance of a high plant density was confirmed in the second season with the largest yield increment of nearly 6 Mg ha^{-1} from the lowest to the highest density. The yield distribution in the second season was less favorable than in the first season yet with an average of close to 19 Mg ha^{-1}. The results of the individual trial analyses from IITA show that tillage remains the major factor suppressing weed infestation with a pronounced effect in the early stages. The weed suppressing

advantage of TME 419 is pronounced in the first season plantings yet negligible in the second season plantings; intercropping and fertilizer application have no effect on weed biomass; the highly variable effect of fertilizer on root yield between seasons and a generally erratic interaction with other factors on cassava root yields are issues that require further research. Intercropping with maize in the second season cannot be recommended owing to significant cassava root yield losses.

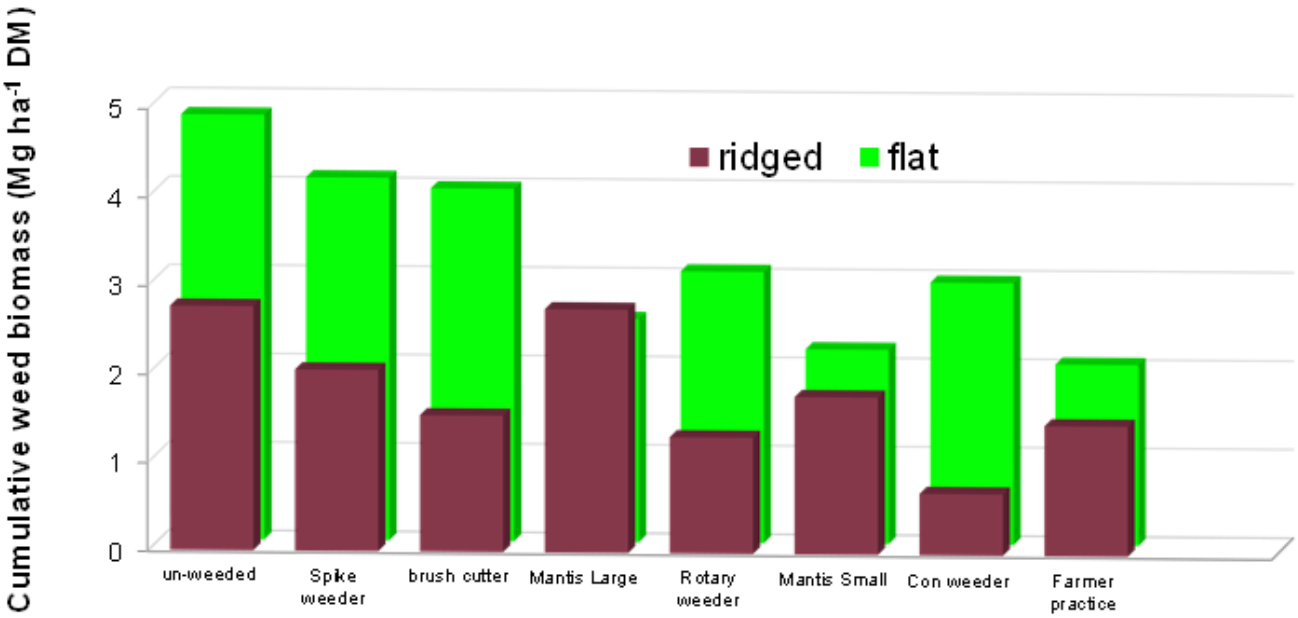


Useful cassava fresh root yield distribution of all 2015 first season planted cassava plots.

Key milestone: Weeding frequency trials established and first results analyzed

Three seasons of weeding frequency trials have been concluded with trials of the last season still in the field. The weeding frequency trials produced data with an unexpectedly high variability within treatments. The sources of such variability are most likely the weed flora which can change on short distances and the weed density in combination with variable soil properties. The latter affect both weed flora and density and cassava performance and there is no information today on how to remove these statistical 'error sources' through well-chosen covariates. For this reason, the data sets are still under investigation with the biometrician trying to figure out which quantifiable variables can be included in the analysis to reduce or explain the excessive variability. However, major results are as follows: soil fertility affects the weeding requirements so that on fertile soils the effects of more frequent weeding are less pronounced than on poor soils; the dominant weed flora determines strongly the effects of different weed control approaches so that on grass-dominated sites the herbicide-based control approaches appear less effective than on sites with a broad leaf dominated weed flora. On infertile soil, dominated by grass weeds, the use of post-emergence herbicides is not as effective as on more fertile soil and a flora dominated by broadleaf weeds. Pre-emergence herbicides combined

with either manual weeding or 1 or 2 post-emergence herbicide applications appear the best option. However, there is a clear tendency towards higher cassava root yields with an increasing frequency of weed control operations. Keeping plots weed-free does not lead to the highest cassava yields, indicating that the crop tolerates the level of competition caused by weed growth when weeded at the usual intervals, 4, 8, 12 and 24 WAP. Determination of weed biomass at harvest indicates that some weed control approaches maintain their control effect while others allow late (after 24 WAP) weed infestation. How far such late weed growth may have a negative effect on root yields should be the subject of further investigations. No weeding at all is most detrimental on poor soils with grass-dominated weed flora; on richer soil, yield losses were only around 40% compared with the treatment with the highest yield.



Cumulative weed biomass as a function of implement and tillage

Key mile stone: Mechanical weeding trials established and first results analyzed

Six mechanical weeding implements were tested on-station in two years to establish which implement performs well in weed control and reduces labor time and drudgery. The short-handled hoe was used as the standard and compared with a long-handled hoe, a spike weeder, a rotary weeder and the engine-driven small and large Mantis, and the brush cutter. A weed-free (hand weeded) and an un-weeded treatment were added as controls. The trial was conducted in a gender-segregated manner to measure if male and female operators would require more or less time to weed and whether preferences differ. None of the mechanical implements allowed significantly faster weeding than the short-handled hoe. Spike and rotary weeders were found to be very slow and strenuous. Both were excluded from follow-up trials on-farm. The brush cutter was relatively fast yet consumed more fuel than the Mantis and the quality of weeding was insufficient to control weeds for any length of time after weeding with the consequence of rapid re-growth. Gender did not affect the time required and preferences were not different. Comparing tools and weeding operations by humans is subject

to differences in skills and physical strength as well as the difference in attitude towards conducting an operation according to the protocol. Although the experimental set-up considered gender and individual differences by clearly scheduled work sequences for each person, individual differences that affected the data set cannot be excluded. The fact that everybody knows how to use a short-handled hoe explains the apparent advantage. It can certainly be expected that with more regular use of the other mechanical implements, the operators' skills will improve and the advantage of the motorized machines will lead to shortened labor times. Another aspect to be considered is that the tool used for weed control is unlikely to have an impact on the root yield as long as the quality of the weed control is the same. Therefore, given similar levels of weed control efficacy of different weeding tools, soil conditions would have more impact on cassava yields than the tool. Considering that the mechanical weeding tools are primarily tested to reduce labor time and drudgery, these aspects will need to be investigated over several seasons with operators being continuously employed and using the machines in a service provision mode.

Different mechanical tools being tested for control in cassava

Objective 2

This Objective seeks to identify effective and safe herbicides for weed control in cassava in Nigeria.

Key Milestone: Quality analysis of cassava roots and leaves treated with herbicides conducted

Following approval from the Project Steering Committee in April, 2016; 47 plant samples comprising 36 cassava samples [roots (12), peels (12), leaves (12)], 8 samples of dry maize grains from the 2015 trial harvested in 2016 and 3 dummy cassava samples [roots (1), peels (1), leaves (1)] were sent to the Pacific Agricultural Laboratory [PAL] at 21830 SW Alexander Lane, Sherwood, Oregon State, USA, on 14 June, 2016. Dummy samples were included as check in the laboratory analyses. PAL has ISO/IEC 17025:2005 accreditation in USA for the analysis of agricultural pesticides. Plant samples were sent with a comprehensive list of active ingredients of each herbicide to be tested against each sample. PAL confirmed availability of Analytical Standards of active ingredients to be tested. Three of the Analytical Standards of active ingredients not available in PAL were sourced from companies that own the active ingredients. Valent provided the Analytical Standard of Pyroxasulfone; Bayer Crop Science now Bayer AG provided that of Formamsulfuron, and Lodosulfuron. In all the samples tested, no residues were detected above the Limit of Quantification [LOQ] of residues (mg/kg). LOQ is the lowest concentration (mg/kg) that can be detected in the sample (lower limit of quantification). The result therefore suggests that the roots, peels, leaves of cassava and maize grains from fields treated with the herbicides under evaluation are safe for consumption by humans and livestock.

Key Milestone: Extensive testing of best herbicides in cassava cropping situation facilitated.
Output 5: Extensive testing of best candidate herbicides in cassava cropping situation at the three agroecological zones is carried out in Year 2.

For this key milestone, crop vigor and injury rating, maize grain yield and weed control efficacy of herbicides tested were reported in the 2015 annual progress report. Cassava root yield from the trials was not reported in 2015 because cassava was harvested at 10 months after planting (MAP). The result of cassava yield and its components from trials for this key milestone are therefore presented. Research methodology is repeated here for clarity of the results.

Methodology of field experiments: Field experiments were carried out in 2015 in different sites in three distinct agroecological zones in Nigeria. The experiments were (1) Extensive testing of pre-emergence herbicides followed by post-emergence herbicides in sole cassava; (2) Extensive testing of pre-emergence herbicides followed by post-emergence herbicides in cassava/maize intercrop; (3) Rate study for pre–emergence herbicides to determine appropriate dose to be used, and (4) Determination of time of application of supplementary post-emergence herbicides in sole cassava and cassava intercropped with maize. Experiment 4 was subsumed in experiments 1 and 2.

Experiments 1 and 2 were set up as split plot arrangement in a Randomized Complete Block Design (RCBD) replicated three times. Twelve pre-emergence herbicides [with Primextra Gold as check] were on the main plot. Five post-emergence herbicides and two untreated plots [Zero post (without any post-emergence herbicides) and No pre-emergence herbicide with 3 hoe-weedings at 4, 8 and 12 WAP] were the subplot treatments. The "No pre-emergence + hoe weeded" subplot treatment was not included in experiment 2. In both experiments, untreated weedy plots were included to provide information on weed spectrum at each site. Based on field observation of weed composition at all sites, the post-emergence herbicide in the subplot treatment was modified. Cobra, a broadleaf herbicide, was replaced with sequential application of Select Max (a grass herbicide) and Cobra starting with Select Max to control both broadleaves and grasses. Similarly, Select Max was replaced by Envoke to control broadleaves, grasses and sedges. Experiment 3 was set-up as an RCBD replicated three times. Two rates of each herbicide used in experiments 1 and 2 were tested. For all the experiments, plot size for each treatment was 4 m × 4 m. An erect cassava variety, TME 419, was used in the evaluation. Cassava was planted at 12,500 plants/ha in all experiments. Maize variety TZL COMP 3 CT DT was used in the cassava/maize intercrop. Maize was planted at a population of 40,000 plants/ha. At each site, glyphosate was applied to the original vegetation and two weeks were allowed before plowing. All fields were harrowed twice except the FUNAAB-Abeokuta fields (harrowed once) before ridging and planting crops. All post-emergence herbicide applications were targeted to weeds under the cassava canopy with a shield.

Results of cassava yield from experiment 1 [Extensive testing of pre-emergence herbicides followed by post-emergence herbicides in sole cassava]

At the IITA-Ibadan site in Oyo State (Derived Savanna agroecology), cassava plant stand, numbers of roots, and fresh stem and fresh root weights did not differ significantly among pre- and post-emergence herbicide treatments tested. Plots treated with Merlin Total + 1 hoe weeding, Primextra + MaisTer

Power at 1.5 L/ha, Codal Gold + 1 hoe-weeding, Merlin Total + Select Max and Cobra, Authority + 1 hoe-weeding, Authority + MaisTer Power at 1.5 L/ha and Codal + MaisTer Power at 1.5 L/ha produced 3.2-7.2 t/ha of fresh roots above plots hoe-weeded three times at 4, 8 and 12 WAP without any herbicides. Although the interaction between pre- and post-emergence herbicide treatments was not significant, plots treated with Goal 4F + MaisTer Power at 1.5 L/ha produced 9.9 t/ha of fresh roots above the control plot (No pre-emergence + 3 timely hoe weedings). In decreasing order of importance, plots treated with Goal + MaisTer Power at 1.5 L/ha [36.2 t/ha] > Codal Gold + MaisTer

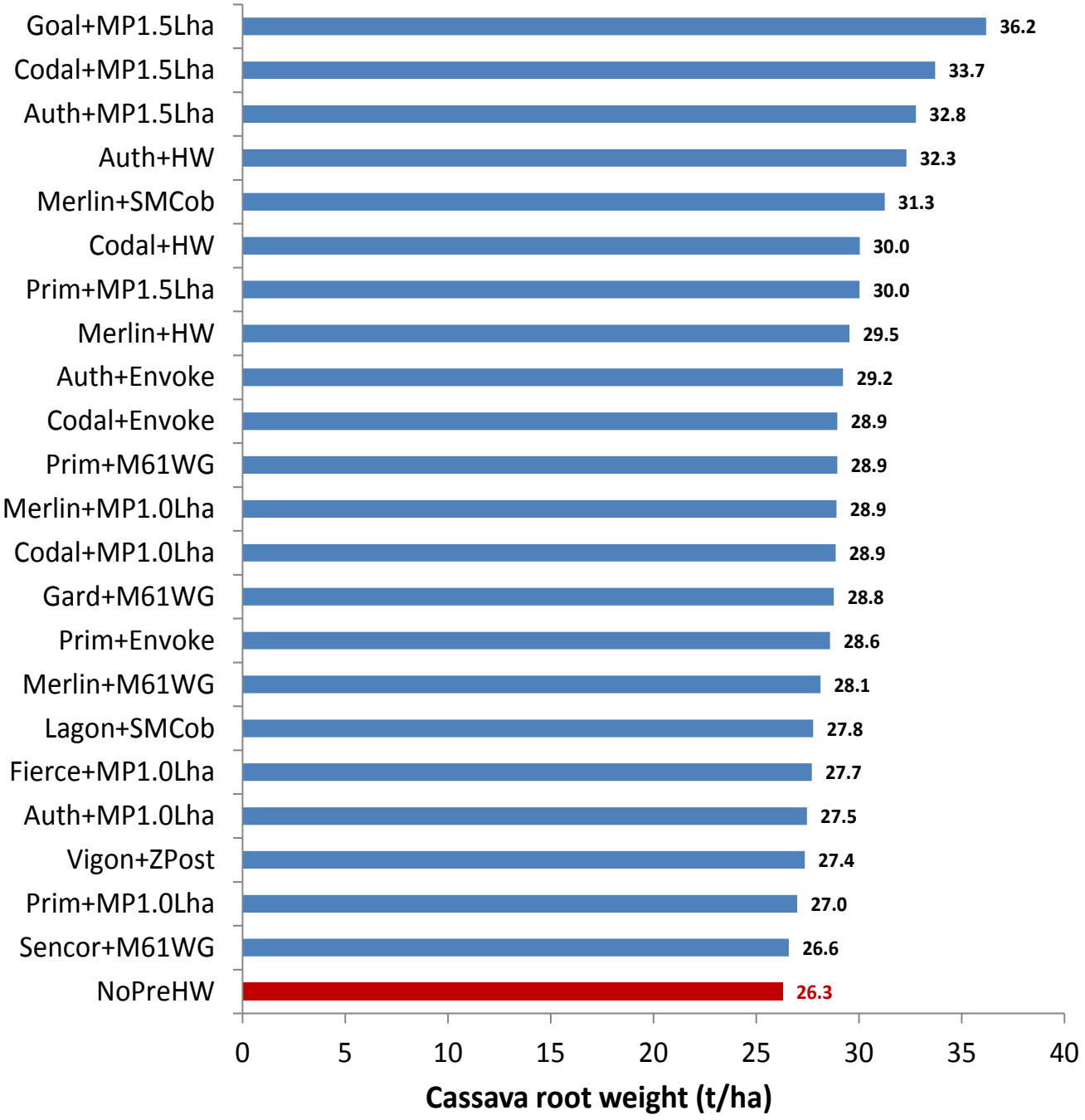


Figure 1: Pre-and post-emergence treatment interaction effects on cassava root weight at IITA site in Oyo State in 2015.

Y-axis legends are: Goal+MP1.5Lha = Goal+Maister Power at 1.5L/ha, Codal+MP1.5L/ha = Codal + Maister Power at 1.5 L/ha, Auth+MP1.5L/ha = Authority + Maister Power at 1.5 L/ha, Auth+HW=Authority+ 1 hoe weeding, Merlin+SMCob=Merlin Total+Select Max+Cobra, Codal+HW=Codal+1 hoe weeding, Prim+MP1.5L/ha=Primextra+MaisTer Power at1.5L/ha, Merlin+HW=Merlin Total+1 hoe weeding, Auth+Envoke=Authority+Envoke, Prim+M61WG=Primextra+MaisTer 61 WG, Merlin+M61WG=Merlin Total + Maister 61 WG, Lagon+SMCob=Lagon+Select Max + Cobra, Fierce+MP1.0Lha=Fierce+MaisTer Power at 1.0 L/ha, Auth+MP1.0Lha=Authority+Maister Power at 1.0 L/ha, Vigon+ZPost=Vigon+Zero Post-emergence herbicide, Prim+MP1.0L/ha = Primextra+Maistser Power at 1.0 L/ha, Sencor + M61WG=Sencor + Maister 61 WG, NoPreHW = No pre-emergence herbicides but hoe weeded three times at 4, 8, and 12 WAP.

Power at 1.5 L/ha [33.7 t/ha] > Authority + MaisTer Power at 1.5 L/ha [32.8 t/ha] > Authority + 1 hoe weeding [32.3 t/ha] > Merlin Total + Select Max and Cobra [31.3 t/ha] had higher fresh root yields than the other treatments.

At the FUNAAB-Abeokuta site in Ogun State (Humid Forest agroecology), plant stand, number of stems and roots, fresh stem and root weights did not vary significantly among pre- and post-emergence herbicide treatments. Pre- by post-emergence treatment interaction effects on fresh root weight were not significant.

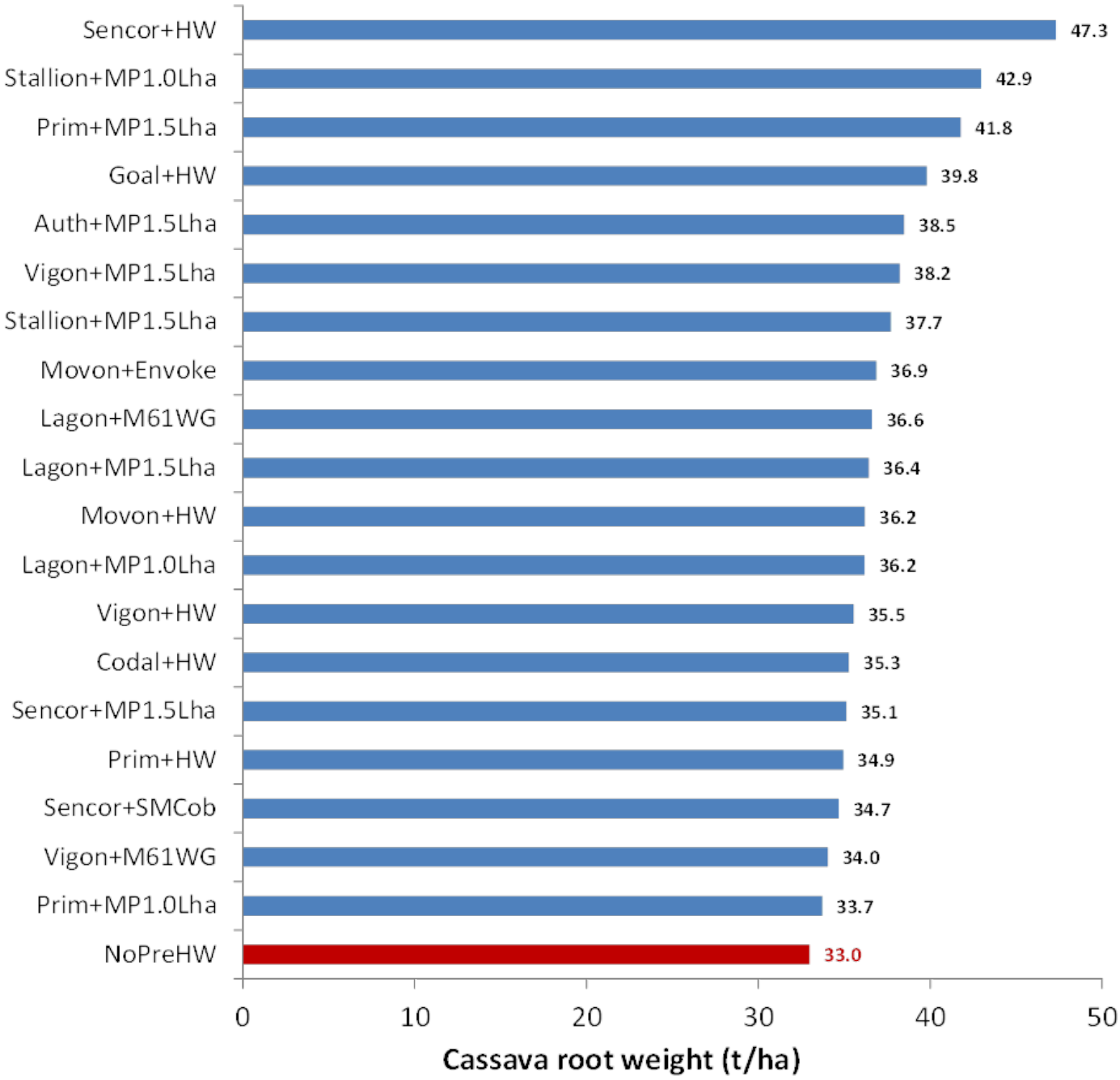


Figure 2: Pre-and post-emergence treatment interaction effects on cassava root weight at FUNAAB cassava monocrop site in Ogun State in 2015.

Y-axis legends are: Sencor + HW = Sencor Plus + 1 hoe weeding, Stallion + MP1.0LH = Stallion + Maister Power at 1.0 L/ha, Prim + MP1.5L/ha = Primextra + Maister Power at 1.5L/ha, Goal + HW = Goal 4F + 1 hoe weeding, Auth + MP1.5L/ha = Authority + Maister Power at 1.5 L/ha, Vigon + MP1.5L/ha = Vigion + Maister Power at 1.5L/ha, Stallion + MP1.5Lha = Stallion + Maister Power at 1.5L/ha, Lagon + M61WG = Lagon+ MaisTer 61 WG, Lagon + MP1.5Lha = Lagon + MaisTer Power at 1.5L/ha, Vigon + HW = Vigon + 1 hoe weeding, Codal + HW = Codal + 1 hoe weeding, Sencor + MP1.5Lha = Sencor + MaisTer Power at 1.5L/ha, Primextra + HW = Primextra + 1 hoe weeding, Sencor + SMCob = Sencor + Select Max + Cobra, Vigon + M61WG= Vigon + Maister 61 WG, Primextra + MP1.5Lha = Primex + Maister Power at 1.5L/ha, NoPreHW = No pre-emergence herbicides but hoe weeded threetimes at 4, 8, and 12 WAP.

However, plots treated with Sencor Plus + 1 hoe weeding produced 14.3 t/ha of fresh roots above the result in the control plot (hoe weeded three times at 4, 8 and 12 WAP without pre-emergence herbicide) [Fig. 2]. Similarly, plots treated with Stallion + MaisTer Power at 1 L/ha (9.9 t/ha) and Primextra+ MaisTer Power at 1.5 L/ha (8.8 t/ha) produced fresh roots above the fresh root weight in the control plot. Authority and Vigon with post-emergence weeding with MaisTer Power at 1.5 L/ha and Codal + 1 hoe weeding produced 5.2 to 6.8 t/ha of fresh cassava roots above the control treatment.

At the UAM-Makurdi site in Benue State (Southern Guinea Savanna agroecology), plant stand, number of stems and roots, fresh stem and fresh root weights did not also vary significantly among pre- and post-emergence herbicide treatments. The interaction between pre- and post-emergence treatments on fresh root weights was not significant, but plots treated with Codal Gold with MaisTer Power at 1.5 L/ha applied post-emergence produced 14.9 t/ha of fresh roots above the control plot (hoe weeded three times - 4, 8 and 12 WAP - without pre-emergence herbicide) [Fig. 3]. Fierce + Select Max and Cobra produced 12.1 t/ha of fresh roots above the control plot. Plots treated with Goal + 1 hoe weeding, Sencor Plus + Envoke, Gardoprim + Select Max and Cobra, Fierce + MaisTer 61 WG, Gardoprim + 1 hoe weeding, Authority + Zero post, Sencor Plus + 1 hoe weeding produced 4.0-7.8 t/ha of fresh roots above the control plot.

Kehinde Johnson of Monsanto (left) presenting a prize to one of the farmers during a knowledge test as part of activities to mark 2016 farmer field days.

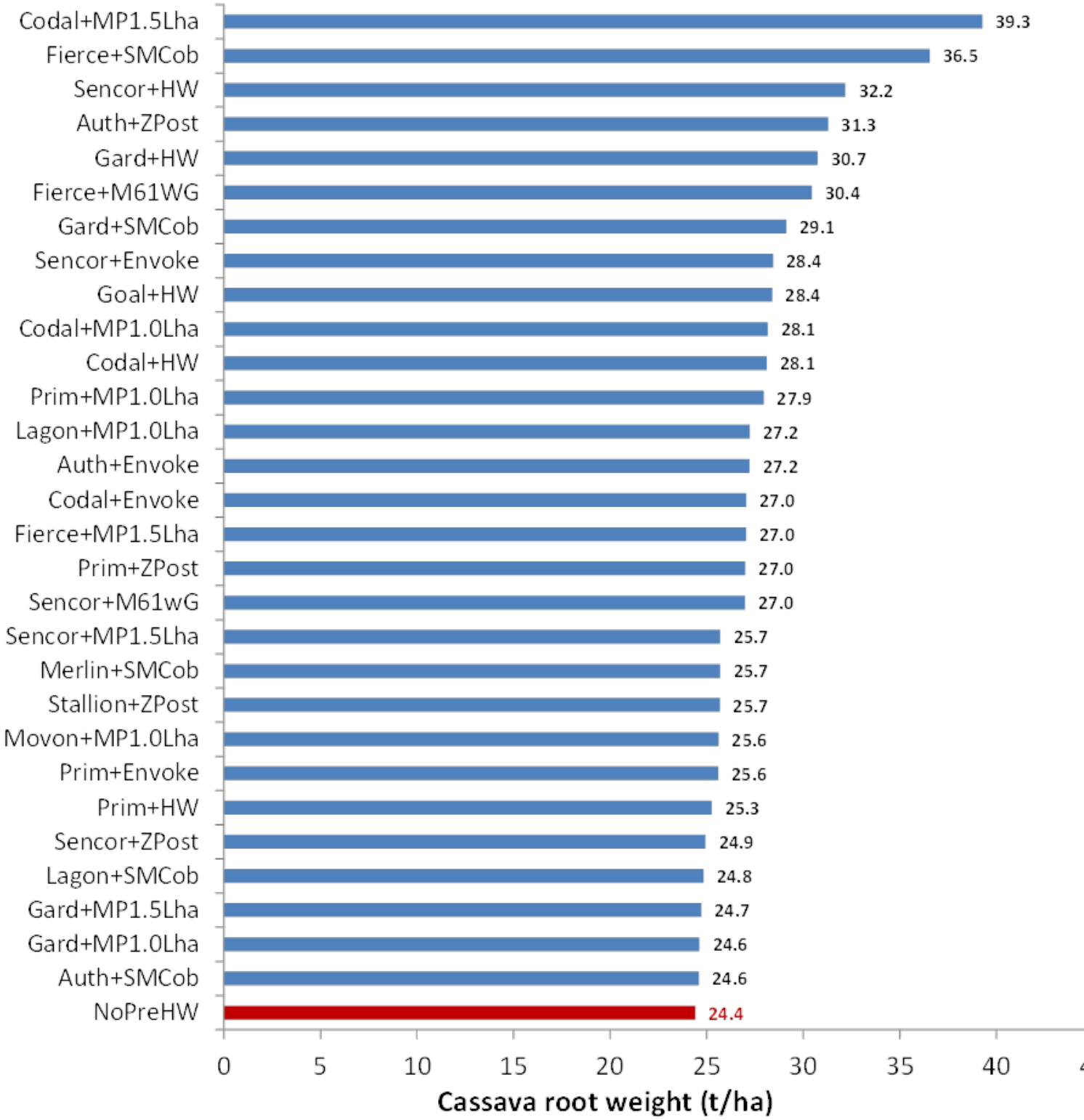


Figure 3: Pre-and post-emergence treatment interaction effects on cassava root weight at UAM cassava monocrop sites in Benue State in 2015.

Y-axis legends are: Codal + MP1.5L/ha = Codal + Maister Power at 1.5 L/ha, Fierce + SMCob = Fierce + Select Max + Cobra, Sencor + HW = Sencor Plus + 1 hoe weeding, Auth + ZPost = Authority + Zero post, Gardoprim + HW = Gardoprim Plus + 1 hoe weeding, Fierce + M61WG= Fierce + Maister 61 WG, Gardoprim + SMCob = Gardoprim + Select Max + Cobra, Goal + HW = Goal + 1 hoe weeding, Codal + MP1.0L/ha = Codal + Maister Power at 1.0 L/ha, Codal + HW = Codal + 1 hoe weeding, Primextra + MP1.0L/ha = Primextra + Maister Power at 1.0 L/ha, Lagon + MP1.0L/ha = Lagon + Maister Power at 1.0 L/ha, Auth + Envoke = Authority + Envoke, Codal + Envoke = Codal + Envoke, Fierce + MP 1.5Lha = Fierce + Maister Power at 1.5L/ha, Prim + ZPost = Primextra + Zero post, Sencor + M61WG= Sencor Plus + Maister 61 WG, Sencor + MP1.5Lha = Sencor Plus + MaisTer Power at 1.5L/ha, Merlin + SMCob = Merlin Total + Select Max + Cobra, Stallion + ZPost = Stallion + Zero post, Movon + MP1.0Lha = Movon + Maister Power at 1.0 L/ha, Primextra + Envoke = Primextra + Envoke, Primextra + HW = Primextra + 1 hoe weeding, Sencor + Z Post = Sencor Plus + Zero post, Lagon + SMCob = Lagon + Select Max + Cobra, Gardoprim + MP1.5L/ha = Gardoprim + Maister Power at 1.5 L/ha, Gardoprim + MP1.0L/ha = Gardoprim + Maister Power at 1.0 L/ha, Authority + SMCob = Authority + Select Max + Cobra,NoPreHW = No pre-emergence herbicides but hoe weeded three at 4, 8, and 12 WAP.

At the NRCRI-Umudike site in Abia State (Humid Forest agroecology), the differences in plant stand, numbers of stems and roots and fresh root weights among pre- and post-emergence herbicides were not significant. Fresh stem weight was significantly higher in plots hoe-weeded three times at 4, 8 and 12 WAP and without any herbicide application. Pre- and post-emergence treatment interaction effects on fresh root weight were not significant but fresh roots in plots treated with Vigon + MaisTer Power at 1.0 L/ha and Fierce + Select Max and Cobra were 6.3 - 6.9 t/ha more than fresh roots obtained from plots hoe weeded three times at 4, 8 and 12 WAP and without any herbicide application [Fig. 4:]. Other treatment combinations that produced > 4 t/ha of fresh roots above the fresh root weight in the control treatment were Stallion + MaisTer 61 WG (4.9 t/ha), Lagon + 1 hoe weeding (4.6 t/ha), Fierce + Envoke (4.4 t/ha), and Vigon + Envoke (4.1 t/ha) [Fig. 4].

Researchers and extension partners sharing knowledge on weed control / safety during the farmer field days

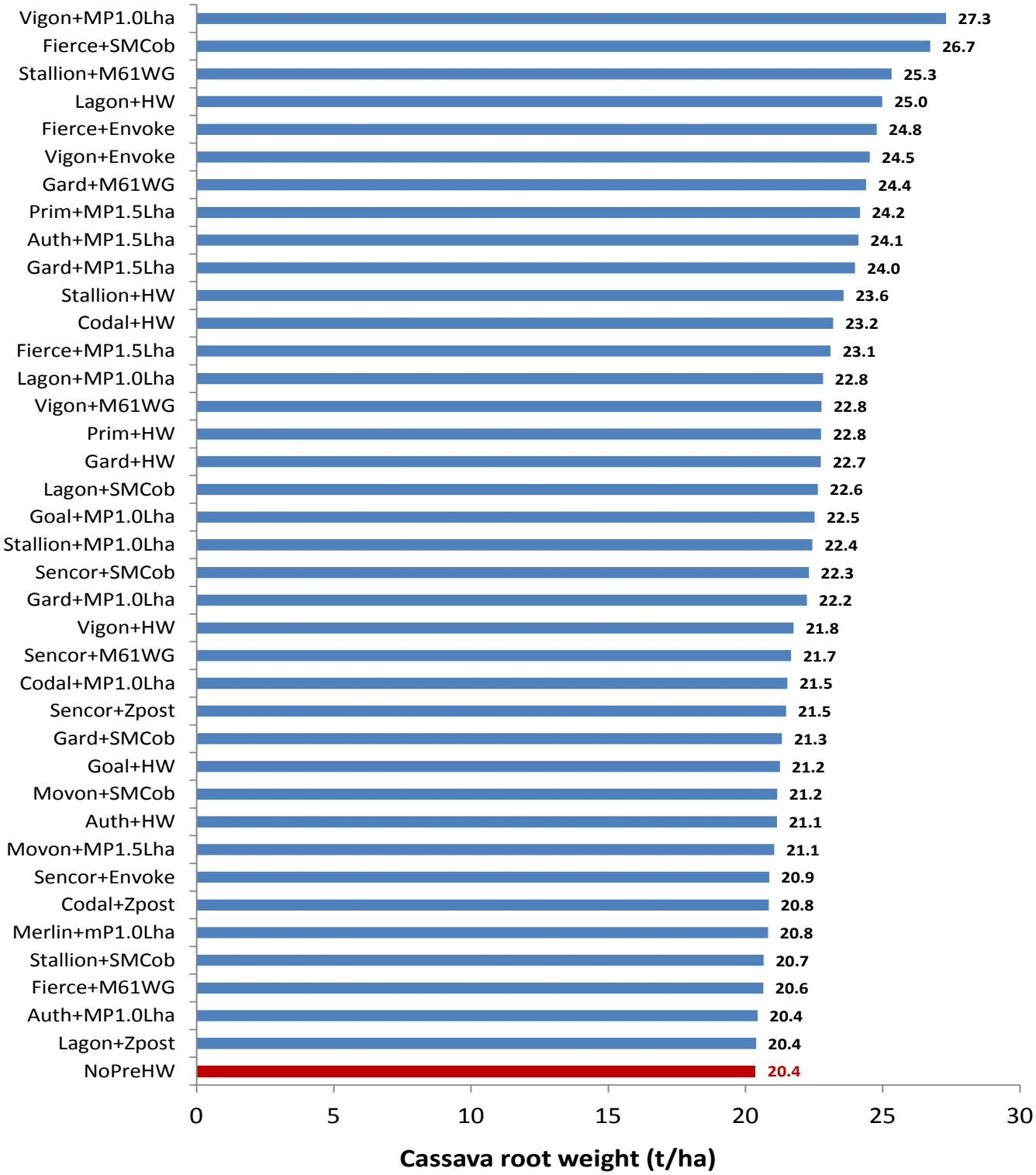


Figure 4: Pre-and post-emergence treatment interaction effects on cassava root weight NRCRI cassava monocrop site in Abia State in 2015.

Y-axis legends are: Vigon + MP1.0L/ha = Vigon + Maister Power at 1.0 L/ha, Fierce + SMCob = Fierce + Select Max + Cobra, Stallion + M61WG = Stallion + Maister 61 WG, Goal + HW = Goal + 1 hoe weeding, Codal + MP1.0L/ha = Codal + Maister Power at 1.0 L/ha, Lagon + HW = Lagon + 1 hoe weeding, Gardoprim + M61WG = Gardoprim + Maister 61 WG, Primextra + MP1.5L/ha = Primextra + Maister Power at 1.5 L/ha, Authority + MP1.5L/ha = Authority + Maister Power at 1.5 L/ha, Gardoprim + MP1.5L/ha = Gardoprim + MaisTer Power at 1.5 L/ha, Stallion + HW = Stallion + 1 hoe weeding, Codal + HW = Codal + 1 hoe weeding, Fierce + MP1.5L/ha = Fierce + Maister Power at 1.5 L/ha, Lagon + MP1.5L/ha = Lagon + Maister Power at 1.5 L/ha, Vigon + M61WG = Vigon + Maister 61 WG, Primextra + HW = Primextra + 1 hoe weeding, Lagon + SMCob = Lagon + Select Max + Cobra, Goal + MP1.0L/ha = Goal + Maister Power at 1.0 L/ha, Stallion + MP1.0L/ha = Stallion + Maister Power at 1.0 L/ha, Sencor + SMCob = Sencor Plus + Select Max + Cobra, Vigon + HW = Vigon + 1 hoe weeding, Sencor + M61WG = Sencor Plus + Maister 61 WG, Codal + MP1.0L/ha = Codal + Maister Power at 1.0 L/ha, Sencor + ZPost = Sencor Plus + Zero post, Gard + SMCob = Gardoprim + Select Max + Cobra, Goal + HW = Goal + 1 hoe weeding, Movon + SMCob = Movon + Select Max + Cobra, Authority + HW = Authority + 1 hoe weeding, Movon + MP1.5L/ha = Movon + Maister Power at 1.5 L/ha, Codal + ZPost = Codal Plus + Zero post, Merlin + MP1.0L/ha = Merlin Total + Maister Power at 1.0 L/ha, Stallion + SMCob = Stallion + Select Max + Cobra, Fierce + M61WG = Fierce + Maister 61 WG, Authority + MP1.0L/ha = Authority + Maister Power at 1.0 L/ha, Lagon + ZPost = Lagon + Zero post, NoPreHW = No pre-emergence herbicides but hoeweed three times at 4, 8, and 12 WAP.

At the University of Uyo-Abak site, Akwa Ibom State, (high rainfall Humid Forest agroecology), the cassava population was affected by termite infestation with 62 - 85% survival of planted stakes. With the exception of number of stems, fresh root weight and yield components were not significantly different among pre- and post-emergence treatments. Although the interaction of pre- and post-emergence treatments on fresh root weight was not significant, fresh root weight from plots treated with Stallion + 1 hoe weeding [32.1 t/ha] more than doubled the fresh root weight from plots hoe weeded three times at 4, 8 and 12 WAP and without any herbicide applied (15.75 t/ha) [Fig. 5]. Plots treated with Fierce + MaisTer Power at 1 L/ha, Movon + MaisTer Power at 1.5 L/ha and Primextra + 1 hoe weeding produced 12.2-12.9 t/ha of fresh roots above the control treatment [Fig. 5]. The following herbicide combinations produced > 5 t/ha of fresh root weight the control treatment: Codal Gold + MaisTer Power at 1.5 L/ha (8.6 t/ha), Gardoprim + MaisTer 61 WG (5.9 t/ha), Codal Gold + MaisTer Power at 1 L/ha (6.5 t/ha), Authority + Envoke (5.7 t/ha), Fierce + 1 hoe weeding (5.7 t/ha), Movon + Envoke (5.4 t/ha) and Merlin + MaisTer Power at 1.5 L/ha (5.4 t/ha).

Researchers on a monitoring visit to trial sites

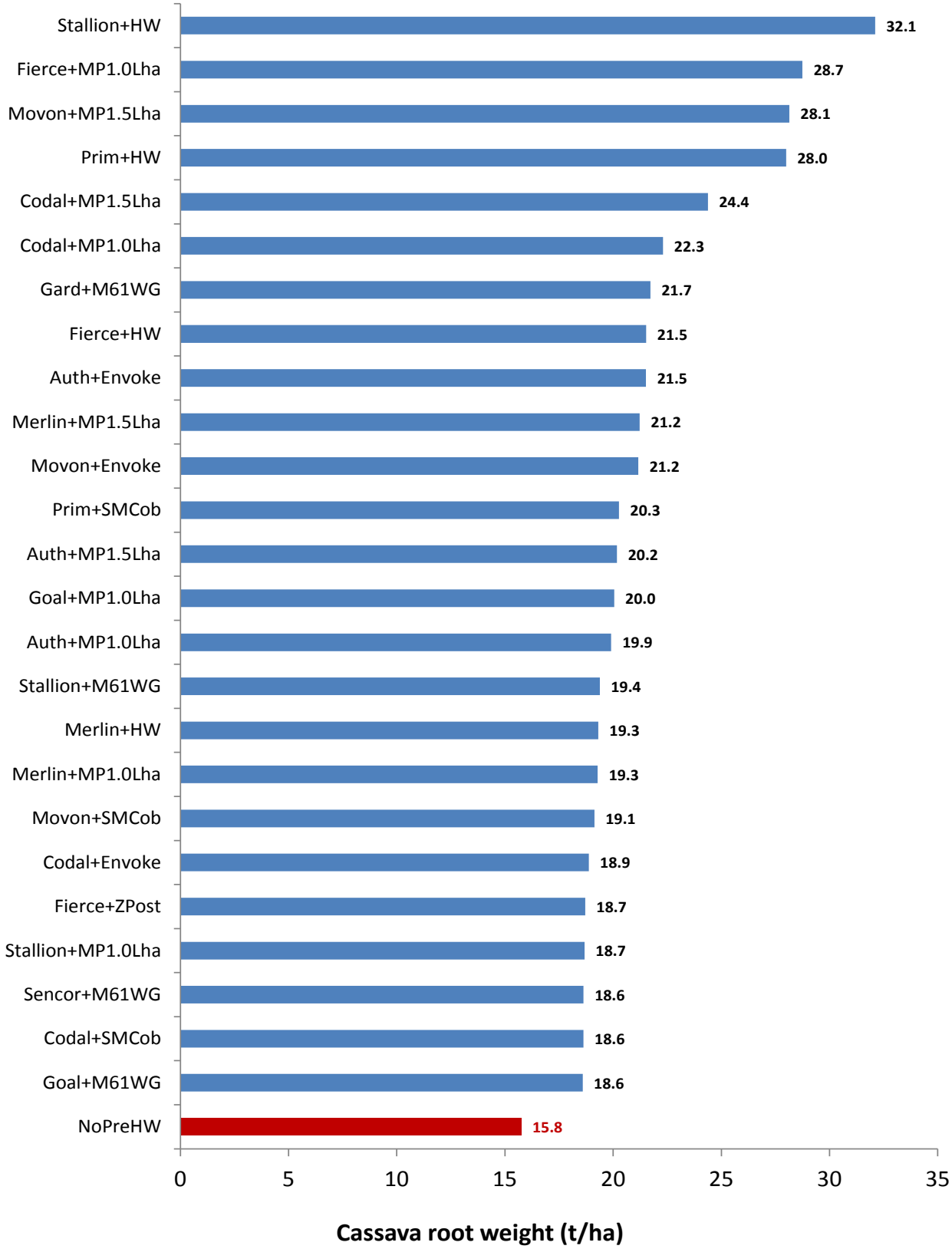


Figure 5: Pre-and post-emergence interaction effects on cassava root weight at AKSU cassava monocrop site in Akwa-Ibom state in 2015.

Y-axis legends are: Stallion + HW = Stallion + 1 hoe weeding, Fierce + MP1.0L/ha = Fierce + Maister Power at 1.0 L/ha, Movon + MP1.5L/ha = Movon + Maister Power at 1.5 L/ha, Primextra + HW = Primextra + 1 hoe weeding, Codal + MP1.5L/ha = Codal + Maister Power at 1.5 L/ha, Codal + MP1.0L/ha = Codal + Maister Power at 1.0 L/ha, Gardoprim + M61WG = Gardoprim + Maister 61 WG, Fierce + HW = Fierce + 1 hoe weeding, Auth + Envoke = Authority + Envoke, Merlin Total+ MP1.5L/ha = Merlin Total + Maister Power at 1.5 L/ha, Primextra + SMCob = Primextra + Select Max + Cobra, Authority+ MP1.5L/ha = Authority + Maister Power at 1.5 L/ha, Goal + MP1.0L/ha = Goal + Maister Power at 1.0 L/ha, Authority + MP1.0L/ha = Authority + Maister Power at 1.0 L/ha, C Merlin Total + HW = Merlin Total + 1 hoe weeding, Merlin Total+ MP1.0L/ha = Merlin Total + Maister Power at 1.0 L/ha, Movon + SMCob = Movon + Select Max + Cobra, Fierce + ZPost = Fierce + Zero post, Stallion + MP1.0L/ha = Stallion + Maister Power at 1.0 L/ha, Sencor + MP1.0L/ha = Sencor Plus + MaisterPower at 1.0 L/ha, Codal + SMCob = Codal + Select Max + Cobra, Goal + SMCob = Goal + Select Max + Cobra,NoPreHW = No pre-emergence herbicides but hoe weeded three times at 4, 8, and 12 WAP.

At the IITA-Onne site in Rivers State (high rainfall Humid Forest agroecology), cassava population
At the IITA-Onne site in Rivers State (high rainfall Humid Forest agroecology), cassava population was generally very low ranging from 45 to 59% of target population. The low population was mainly due to a loss of viability of planting stakes. Variety TME 419 seems to lose viability with prolonged exposure to heat. In general, there was no significant treatment effect on all measured parameters with the exception of root number that differed significantly among the post-emergence treatments. Although the overall interaction effect of pre- and post-emergence treatments on fresh root weight was not significant, plots treated with Stallion and hoe-weeded once produced 16.5 t/ha of fresh roots above the control plot [Fig. 6]. Plots treated with the following herbicides: Codal + Envoke, Gardoprim + Select Max and Cobra, Primextra Gold + Select Max and Cobra, Authority + MaisTer 61 WG, Fierce + MaisTer Power at 1 L/ha, Fierce + MaisTer Power at 1.5 L/ha and Stallion + Select Max and Cobra produced 8-19 t/ha of fresh roots above the control plot.

Combined analysis of all site data: Data from the University of Uyo-Abak and IITA-Onne sites were not included in this analysis because of the low cassava populations. Fresh root weight and other measured yield components varied significantly among sites. The highest fresh root weight was obtained from the FUNAAB-Abeokuta site [Fig. 7]. Averaged across sites and post-emergence treatments, cassava populations and stem and fresh root weights did not vary significantly among pre-emergence herbicide treatments. Number of stems and roots varied significantly among pre-emergence herbicide treatments. Plots treated with Vigon had the highest number of roots compared with the result from plots treated with Fierce, Goal, Merlin Total, Movon and Stallion. Across sites, post-emergence weed control had a significant effect on number of stems and roots, and fresh root weight. Plots treated with pre-emergence herbicides without post-emergence weed control had the lowest ($P = < 0.05$) number of roots and lowest fresh stem and root weights compared with treatments that had pre-emergence herbicide weed control. The following treatment combinations Sencor Plus + 1 hoe weeding [30.3 t/ha]> Fierce + Select Max and Cobra [30 t/ha] >Codal Gold + MaisTer Power at 1.5 L/ha [30.1 t/ha] >Primextra + MaisTer Power at 1.5 L/ha [29.6 t/ha] produced the highest fresh root weight compared with the hoe weeded treatment (done at 4, 8 and 12 WAP) without

Seun Orolakin of Syngenta presenting a prize to a farmer during the farmer field days

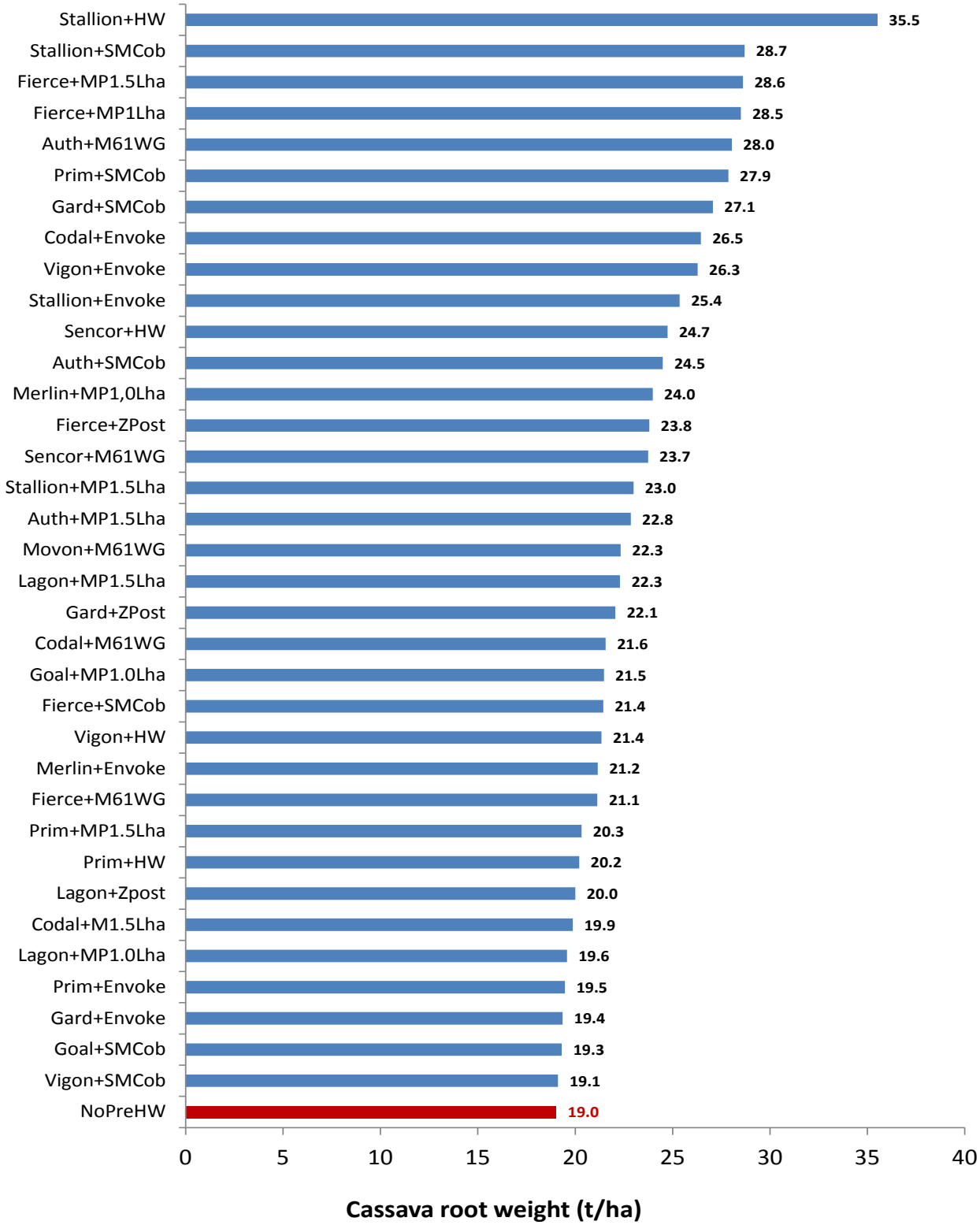


Figure 6: Pre-and post-emergence treatment interaction effects on cassava root weight at IITA cassava monocrop site in Onne, Rivers State in 2015.

Y-axis legends are: Stallion + HW = Stallion + 1 hoe weeding, Stallion + SMCob = Stallion + Select Max + Cobra, Fierce + MP1.5L/ha = Fierce + Maister Power at 1.5 L/ha, Fierce + MP1.0L/ha = Fierce + Maister Power at 1.0 L/ha, Auth + M61WG = Authority + Maister 61 WG, Primextra + SMCob = Primextra + Select Max + Cobra, Gard + SMCob = Gardoprim + Select Max + Cobra, Sencor + HW = Sencor Plus + 1 hoe weeding, Authority + SMCob = Authority + Select Max + Cobra, Merlin + MP1.0L/ha = Merlin Total + Maister Power at 1.0 L/ha, Fierce + ZPost = Fierce + Zero post, Sencor + M61WG = Sencor Plus + Maister 61 WG, Stallion + MP1.5L/ha = Stallion + Maister Power at 1.5 L/ha, Auth + MP1.5L/ha = Authority + Maister Power at 1.5 L/ha, Movon + M61WG = Movon + Maister 61 WG, Lagon + MP1.5L/ha = Lagon + Maister Power at 1.5 L/ha, Gard + ZPost = Gardoprim + Zero post, Codal + M61WG = Codal + Maister 61 WG, Goal + MP1.0L/ha = Goal + Maister Power at 1.0 L/ha, Fierce + SMCob = Fierce + Select Max + Cobra, Vigon + HW = Vigon + 1 hoe weeding, Fierce + M61WG = Fierce + Maister 61 WG, Primextra + MP1.5L/ha = Primextra + Maister Power at 1.5 L/ha, Primextra + HW = Primextra + 1 hoe weeding, Lagon + ZPost = Lagon + Zero post, Codal + MP1.5L/ha = Codal + Maister Power at 1.5 L/ha, Lagon + MP1.0L/ha = Lagon + Maister Power at 1.0 L/ha, Prim + Envoke = Primextra + Envoke, Gard + Envoke = Gardoprim + Envoke, Goal + SMCob = Goal + Select Max + Cobra, Vigon + SMCob = Vigon + Select Max + Cobra,NoPreHW = No pre-emergence herbicides but hoe weeded three times at 4, 8, and 12 WAP.

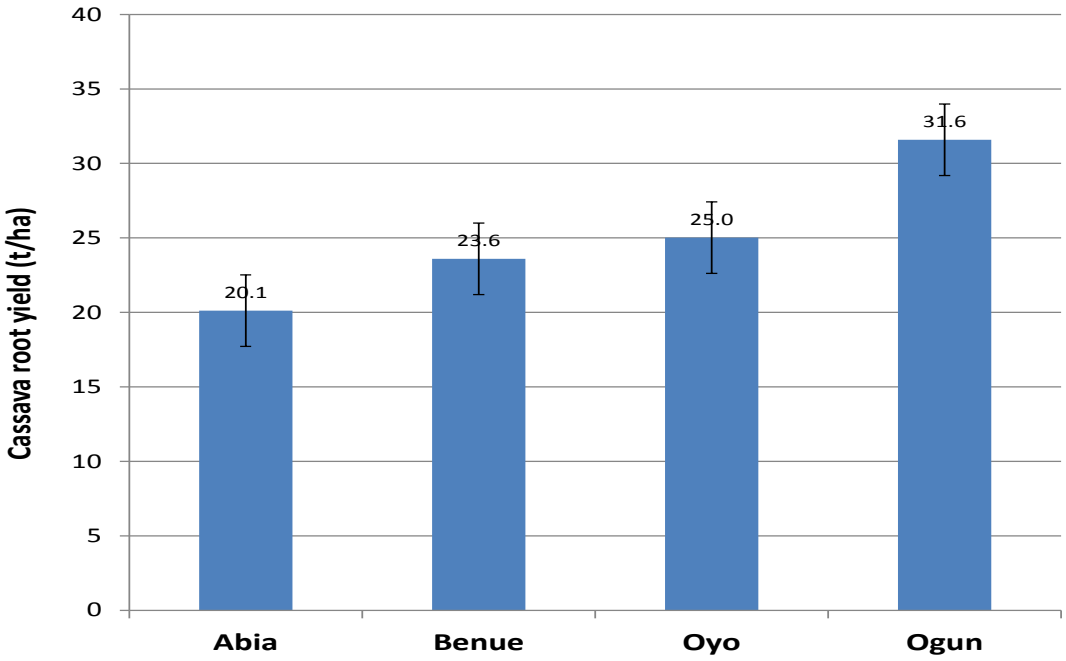


Figure 7: Average weight fresh roots in response to pre- and post-emergence weed control in Abia, Benue, Oyo, and Ogun States in 2015.

any herbicides.

Result of cassava yield from experiment 2: [Extensive testing of pre-emergence herbicides followed by post emergence herbicides in cassava/maize intercrop]

At the IITA-Ibadan site in Oyo State, fresh root weight and yield components did not differ significantly among pre- and post-emergence herbicide treatments with the exception of stem weight which varied significantly among post-emergence treatments. Plots treated with MaisTer Power at 1.0 L/ha and MaisTer 61 WG had the highest cassava stem weight. Plots treated with Fierce produced 7.34 to 9.47 t/ha of fresh cassava roots above the fresh root weights in plots treated with Authority, Codal Gold, Gardoprim, and Lagon. Plots treated with Sencor Plus + MaisTer Power at 1.5 L/ha produced 9.8 t/ha of fresh roots above the root yield in the hoe weeded control plot. Similarly, plots treated with Fierce + MaisTerPower at 1.5 L/ha, Primextra + MaisTer Power at 1.0 L/ha and Marlin Total at 1.5 L/ha produced 6 t/ha of fresh roots above the hoe weeded plot.

At the FUNAAB-Abeokuta site in Ogun State, cassava population, stem and fresh root weight was not significantly different among pre-emergence herbicides. However, number of stems and roots varied significantly among pre-emergence herbicides. Plots treated with Gardoprim produced significantly more stems than plots treated with Merlin Total and Sencor Plus but not with the other pre-emergence herbicide treatments. Fresh stems from plots treated with Gardoprim were significantly heavier than those from plots treated with Sencor Plus but not with the other pre-emergence herbicide treatments. Post-emergence weed control had a significant effect on the number of stems and on fresh stem and root weights. Averaged across pre-emergence herbicides, the number of stems in plots treated with MaisTer Power at 1.5 L/ha was significantly higher than from plots treated with Select Max and Cobra, MaisTer Power at 1.0 L/ha and pre-emergence herbicide plots that were hoe weeded once but not with the other treatments. Plots treated with MaisTer Power at 1.0 L/ha had the lowest fresh cassava root weight compared with the other treatments. Although the pre- by post-emergence treatment interaction effect on fresh root weight was not significant, plots treated with Vigon + MaisTer Power at 1.5 L/ha produced the highest fresh root weight compared with plots with the other pre- and post-emergence combinations

of weed control treatments. Plots treated with this herbicide combination had 11.9 t/ha of fresh roots over the hoe weeded plots. Similarly plots treated with the following herbicide combinations: Lagon + Envoke, Merlin Total + MaisTer 61 WG, Primextra + MaisTer Power 61 WG, Goal + MaisTer Power at 1 L/ha, Movon + MaisTer 61 WG and Lagon + Select Max and Cobra produced between 6.2 and 10.8 t/ha of fresh roots above the hoe weeded control.

At UAM-Makurdi site in Benue State, cassava population, stem and root numbers and fresh root weight did not differ significantly among pre-emergence herbicides. A similar trend was observed with the post-emergence weed control treatments for the same set of variables. For stem weight, plots treated with Sencor Plus produced the significantly heaviest stems compared with Primextra plots but not with the other pre-emergence herbicide treatments. Plots treated with Sencor Plus and hoe weeded once produced 13.2 t/ha of fresh roots above the hoe weeded control plots. The following treatment combinations produced 5.8-10.4 t/ha of fresh roots above the production in the hoe weeded control treatment: Fierce + MaisTer Power at 1.5 L/ha [10.4 t/ha], Codal + Select Max and Cobra [8.8 t/ha], Stallion + MaisTer 61 WG [8.0 t/ha], Lagon + MaisTer Power at 1.5 L/ha [7.3 t/ha], Gardoprim + Select Max and Cobra [5.8 t/ha].

Combined analysis of all site data: Results from the data from three cassava/maize intercrop sites showed that site had no significant effect on fresh root weight [UAM-Makurdi, Benue State = 27 t/ha, IITA-Ibadan, Oyo State = 26 t/ha, FUNAAB-Abeokuta, Ogun State = 24 t/ha]. Cassava population and number of stems varied significantly with pre-emergence herbicide treatments. Plots treated with Primextra had the highest cassava population followed by Codal Gold and Movon. There were no significant differences in number of roots and in stem and fresh root weights among pre-emergence herbicide treatments. Although not significantly different from other treatments, post-emergence weed control with MaisTer Power at 1.5 L/ha produced the highest number of roots and the largest stem and fresh root weights [Table 13: Annex 2.3]. Overall, plots treated with Fierce + MaisTer Power at 1.5 L/ha [31.4 t/ha], Merlin + MaisTer 61 WAP [31.1 t/ha], Sencor Plus + 1 hoe weeding [30.7 t/ha] and Primextra + MaisTer Power at 1.5 L/ha [30.0 t/ha] had the highest fresh root weight producing 3.6-5.4 t/ha of fresh roots above the hoe weeded control plot.

Harvested cassava from one of the fields

Objective 3

Key milestone: Newly identified pre-emergence herbicides integrated with improved agronomic practices are tested for weed control efficacy and optimum crop yield (cassava and companion crop yields) in Year 3 and onwards.

Key milestone: Newly identified pre-emergence herbicides complemented with post-emergence herbicides and integrated with improved agronomic practices are tested for weed control efficacy and optimum crop yield (cassava and companion crop yields) in Year 3 and onwards.

The two key milestones of Objective 3 (stated above) were integrated into the same trials. Results under the two key milestones are presented together.

Methodology: On-farm researcher-managed weed control trials were conducted in 58 farmers' fields in four States [Abia = 14, Ogun = 14; Benue = 14, Oyo = 16] in the 2016 growing season in Nigeria. The 58 on-farm trials consisted of 8 mechanical on-farm trials where chemical treatment was not applied. The remaining 50 on-farm trials had herbicide treatments incorporated in an integrated manner. For the 50 on-farm trials, the number of farmers' fields in each State was split equally for cassava monocrop and cassava/maize intercrop trials. Farmers that participated in the trials were randomly selected from Local Government Areas and communities where the Project had earlier conducted a baseline and Knowledge, Attitudes and Practices (KAP) study. Initial vegetation in experimental sites was slashed and tree stumps removed where necessary. Perennial weeds such as *Imperata cylindrica, Panicum maximum* and *Cyperus rotundus* were killed with glyphosate. The weed control trials in the cassava monocrop farmers' fields were set up as a split plot with 6 pre-emergence herbicides and a no herbicide treatment as main plots; and 4 post-emergence herbicides, weeding with a small Mantis machine, long- and short-handled hoes and a zero post-emergence treatment in the subplots within each main plot. Main plots and subplots within main plots were randomly assigned. The weed control trials in the cassava/maize intercrop fields were set up also as a split plot with 5 pre-emergence herbicides and one non-pre-emergence herbicide plot as main plot; and 2 post-emergence herbicides, weeding with a small Mantis machine, long- and short-handled hoes and a zero post-emergence treatment in the subplots. Farmers were replicates. Farmer-managed plots were established close to the on-farm weed management trials. The following combination of agronomic factors was used in all plots, (a) variety: TME 419; (b) tillage: ridged; (c) plant density: 12500 plants/ha; (d) fertilizer applied. Cassava sprout and maize germination counts were taken. Crop phytotoxicity and weed control efficacy assessments were carried out. Maize was harvested green and income from the sale of marketable green cobs was estimated.

Cassava sprout count

In the cassava monocrop, pre-emergence herbicides affected cassava sprouting significantly in all the farm sites across four States. Across all farm sites, Merlin Total at 0.5 L/ha and Sencor plus at

1.5 L/ha significantly delayed sprouting of cassava. These herbicides suppressed the exposed buds on the cassava stakes above the soil surface. Only buds at the buried end of the stakes sprouted and consequently emerged late from the soil. At 6 WAP, 82-99.2% of target cassava population was achieved across all farm sites with the exception of Merlin Total in farm sites in Ogun State which had only 75% of target population. In cassava/maize intercrop across all farm sites, pre-emergence herbicides did not affect cassava sprouting significantly at 4 and 6 WAP. With the exception of Gardoprim at farm sites in Oyo State, 80.3-94.4% of the target cassava population was achieved at 4 WAP. At 6 WAP, 90-99% of the target cassava population was achieved.

Weed Control Efficacy

In all the farm site trials, weed control efficacy rating was carried before applying any post-emergence treatment.

Cassava/Maize intercrop: At Oyo State farm sites, pre-emergence herbicides varied significantly for both broadleaf and grass control at 4, 6, 8 and 12 WAP. Lagon and Movon controlled grasses better than broadleaves at all sampling dates. Movon provided 83% control of grasses with post-emergence weed control at 4 WAP in 3 out of 7 sites. Broadleaf weeds were controlled 80% by Fierce and 83% by Gardoprim at 6 WAP and declined to 75% and 78% of the control, respectively, at 8 WAP without any post-emergence weed control. Fierce, Gardoprim and Primextra provided good control of grasses at 8 WAP without any post-emergence weed control. All plots where pre-emergence herbicide was not applied received post-emergence weed control at 4 WAP. At all sampling dates, weed control in plots where pre-emergence herbicide was not applied was poor (30-67%) except at 8 WAP for grasses. Fierce had the best weed control providing 80% control of all weeds up to 8 WAP without post-emergence weed control compared with the other pre-emergence herbicides. Broadleaf weed control in plots treated with Fierce, Gardoprim and Primextra was similar. Broadleaf weed control in plots treated with Lagon and Movon was poor even after post-emergence weed control in 2 sites out of 7 sites for Lagon, and 3 sites out of 7 sites for Movon. In a decreasing order of importance, Fierce > Gardoprim > Primextra provided good control of grasses up to 8 WAP without post-emergence weed control. Pre- by post-emergence treatment interaction effects on broadleaf and total weed control were not significant. Fierce provided 80% control of broadleaves and 89% of grasses up to 8 WAP without post-emergence weed control. Gardoprim and Primextra provided 76% and 74% control of broadleaves, and 86% and 84% control of grasses, respectively, up to 8 WAP without post-emergence weed control. Lagon and Movon could not control broadleaf weeds well up to 8 WAP without post-emergence weed control but were able to maintain an acceptable level of grass weed control.

At Ogun State farm sites, pre-emergence herbicides differed significantly for both broadleaf and grass control at 4 WAP, but not at 6 and 10 WAP. At all farm sites, the “no-pre-emergence herbicide” main plot received post-emergence weed control at 4 WAP. Overall, pre-emergence herbicides had 75-79% control of broadleaf weeds at 6 WAP. Although there was no significant difference in broadleaf weed control among the different pre-emergence herbicides, broadleaf weed control in plots treated with Fierce tended to be higher (79%). All pre-emergence herbicides controlled grasses by 80-89% up to 6 WAP before post-emergence weed control was applied. All pre-emergence herbicides did not provide good control of broadleaves up to 10 WAP without post-emergence weed control. Post-

emergence weed control with either MaisTer Power or MaisTer 61 WG at 6 WAP in plots treated with Lagon provided 80% control of broadleaves and 89% control of grasses at 10 WAP. In the "no pre-emergence herbicide" plots, post-emergence application of MaisTer Power at 4 WAP provided 83% control of broadleaf weeds at 10 WAP. Post-emergence application of MaisTer Power at 6 WAP in plots treated with Fierce, Gardoprim, Movon and Primextra provided 70-77% control of broadleaf weeds up to 10 WAP. A similar trend was obtained with application of MaisTer 61 WG at 6 WAP in plots treated with Gardoprim and Movon as pre-emergence herbicides. Fierce had better broadleaf weed control than the other pre-emergence herbicides. For grasses, post-emergence application of MaisTer Power at 6 WAP in plot treated with Gardoprim, Lagon, Movon and Primextra provided 80-87% control of this weed at 10 WAP. With the exception of Lagon that provided 83% control of grasses up to 10 WAP without post-emergence weed control, all other pre-emergence herbicides had 70-71% control of grasses up to 10 WAP. Based on weed control efficacy, Lagon followed by Fierce, Gardoprim and Primextra in combination with MaisTer Power as post-emergence herbicide could be suggested to farmers for weed control in cassava/maize intercrop. Post-emergence weed control with long- and short-handled hoes and small Mantis rotary weeder in plots treated with Fierce, Gardoprim, Movon and Primextra had similar control of grasses and therefore could be suitable alternatives to post-emergence weed control with MaisTer Power.

At the Benue State farm sites, the 'no pre-emergence' herbicide main plot received post-emergence weed control at 5 WAP. Application of post-emergence weed control in this main plot did not control weeds effectively. Overall, broadleaf and grass weed control was significantly better in plots treated with pre-emergence herbicides compared to plots without pre-emergence herbicides. At 6 WAP, all pre-emergence herbicides provided good (80-89%) control of broadleaves and grasses. Although the differences in weed control efficacy among the pre-emergence herbicides were not significant, Fierce had better weed control of broadleaves and grasses at 8 WAP than other pre-emergence herbicide treatments. Plots treated with Gardoprim, Lagon, Movon and Primextra received post-emergence weed control in 2 out of 5 sites at 6 WAP. Fierce provided good to excellent (83-90%) control of broadleaves and grasses at 8 WAP without any post-emergence weed control. With post-emergence weed control at 6 WAP, Gardoprim and Lagon provided 80% control of broadleaves and 72-77% of grasses up to 8 WAP. Although Movon and Primextra plots had post-emergence weed control at 6 WAP, they were not as good as the other pre-emergence herbicides in broadleaf control.

At the Abia State farm sites, the 'no pre-emergence herbicide' main plot had significantly more weeds than plots treated with pre-emergence herbicides except at 6 WAP for total weeds and grasses.'No pre-emergence herbicide' main plots received post-emergence control at 4 WAP except in one site where post-emergence weed control was applied at 3 WAP. At 6 WAP, all pre-emergence herbicides were similar in providing good control of broadleaves and grasses. All pre-emergence herbicide plots received post-emergence weed control at 6 WAP. Although there was no significant difference in weed control efficacy among the pre-emergence herbicides, Fierce followed by Gardorprim had 80-81% control of broadleaf weeds. Similarly, Movon followed by Fierce, Gardoprim and Lagon controlled grasses better than Primextra Gold. Movon maintained good control of broadleaves and grasses up to 10 WAP. Post-emergence weed control in the 'no pre-emergence herbicide' plots did not result in good weed control after 6 WAP. Pre- by post-emergence treatment interaction effects on broadleaf and grass control were significant. With post-emergence weed control at 6 WAP, Fierce followed by Movon, Gardoprim and Lagon provided better (80-83%)

control of broadleaves and grasses up to 8 WAP Primextra (73-77%). In the Primextra main plots, post-emergence weed control with the small Mantis motorized weeder and MaisTer Power at 6 WAP provided better (80-83%) weed control compared to other post-emergence weed control treatments in this main plot. At 8 WAP, broadleaf and grass weed control in plots treated with Fierce without post-emergence weed control was similar to those in Fierce plots that had post-emergence weed control with the small Mantis weeder, MaisTer Power, short- and long-handled hoe at 6 WAP. Similarly, plots treated with Gardoprim without post-emergence weed control had similar broadleaf and grass control as Gardoprim plots in which post-emergence weed control was carried out with MaisTer 61 WG, MaisTer Power, the small Mantis weeder or short-handled hoe at 6 WAP. At 8 WAP, a similar trend in broadleaf and grass weed control was observed between Lagon plots without post-emergence control and Lagon plots in which post-emergence weed control was carried with the small Mantis weeder and MaisTer Power at 6 WAP. Movon plus post-emergence weed control with the short- and long-handled hoe, MaisTer 61 WG at 6 WAP provided 83% control of grasses while Primextra plus post-emergence weeding at 6 WAP with the small Mantis weeder, MaisTer Power and MaisTer 61 WG provided 80-83% control of broadleaves and grasses. Based on weed control efficacy result, Fierce followed by Gardoprim and Lagon could be suggested to farmers for pre-emergence weed control in cassava/ maize intercrop.

Cassava monocrop:

At Oyo State farm sites, plots treated with pre-emergence herbicides had significantly better weed control than the 'no pre-emergence herbicide' plots at all sampling dates except at 8 WAP for grasses. All "no pre-emergence herbicide" main plots had post-emergence weed control at 4 WAP. At 8 WAP, Merlin Total and Sencor Plus provided 84% and 87% control of broadleaf weeds respectively without post-emergence weed control. Merlin Total and Gardoprim had excellent control of grasses up to 8 WAP without post-emergence weed control. All plots treated with pre-emergence herbicides had post-emergence weed control at 8 WAP with the exception of Merlin Total and Sencor Plus. Plots treated with Merlin Total and Sencor Plus did not receive post-emergence weed control until 12 WAP. Fierce and Gardoprim without post-emergence weed control provided 70-73% of broadleaf control and 90% of grass control at 8 WAP. Merlin Total and Primextra both provided 90% control of broadleaves and 83% and 88% control of grasses, respectively, up to 8 WAP without post-emergence weed control.

At Ogun State farm sites, weed control efficacy in plots treated with pre-emergence herbicides was significantly different from those in the 'no pre-emergence herbicide' plots at all sampling dates except at 6 and 8 WAP for grasses. All "no pre-emergence herbicide" main plots had post-emergence weed control at 4 WAP. With the exception of Merlin Total, all pre-emergence herbicides plots received post-emergence weed control at 6 and 7 WAP. There was significant pre- by post-emergence treatment interaction effects on broadleaf weed control. Without post-emergence weed control, Fierce, Gardoprim and Sencor Plus provided 72-75% control of total and broadleaf weeds up to 8 WAP. At 8 WAP, weed control in Movon and Primextra plots without post-emergence weed control was poor. Plots treated with Fierce, Gardoprim, Sencor Plus and Merlin Total provided 80-83% control of broadleaf weeds up to 8 WAP without post-emergence weed control. Merlin Total provided excellent control (93%) of grasses up to 8 WAP without post-emergence weed control.

At Benue State farm sites, post-emergence weed control in plots treated with pre-emergence herbicides led to significant weed control at 8 and 12 WAP. Weed control efficacy was significantly higher in plots treated with Sencor Plus followed by Merlin Total and Fierce at 8 WAP. In general, pre-emergence herbicides plots received post-emergence weed control at 6 and 7 WAP in most sites. Plots treated with Merlin Total had post-emergence weed control at 7 WAP in 2 out of 5 sites only. Post-emergence weed control in all pre-emergence herbicide plots at 6 to 7 WAP provided 80-84% control of broadleaves and grasses at 12 WAP. Although the interaction between pre- and post-emergence treatments did not have a significant effect on broadleaves and grasses at 8 WAP, Sencor Plus followed by Merlin Total without post-emergence weed control (Sencor + Zero post (without any post emergence treatment), Merlin + Zero Post (without any post-emergence treatment)) provided 88-93% control of broadleaves and grasses at 8 WAP. At 12 WAP, pre- by post-emergence treatment interaction effect on broadleaves and grasses was significant. In general, post-emergence weed control with glyphosate at 6 and 7 WAP in all plots treated with pre-emergence herbicides provided 90% weed control. Post-emergence weed control with post-emergence herbicides and the motorized weeder at 6 and 7 WAP in plots treated with Gardoprim and Merlin Total provided 80-88% control of broadleaves and grasses at 12 WAP. In the absence of post-emergence weed control, Sencor Plus and Merlin Total provided 88% control of grasses while Merlin Total and Sencor Plus provided 88% control of broadleaves and 90% control of grasses at 12 WAP. Fierce and Gardoprim Plus Gold had 70-73% control of broadleaves and good (80-83%) control of grasses at 12 WAP without post-emergence weed control. Movon without any post-emergence treatment controlled 70% of broadleaves and 78% of grasses at 12 WAP.

At Abia State farm sites, pre-emergence herbicides provided better weed control at all sampling dates compared with post-emergence weed control alone. However, weed control in this zone was not as efficient as that observed in the other States. At 6 WAP, Merlin Total, Gardoprim and Primextra provided 80-81% control of broadleaves and grasses. With the exception of Merlin Total, Primextra and Gardoprim, pre-emergence herbicides provided 71-79% control of broadleaves and grasses at 10 WAP. There was significant pre- by post-emergence treatment interaction effect on broadleaf and grass control. Without post-emergence weed control, Sencor Plus (Sencor Plus + zero post (without any post-emergence treatment)) provided 80% control of grasses at 8 WAP. All pre-emergence herbicides provided 71-79% control of broadleaves and grasses with the exception of Fierce + Select Max and Cobra and Merlin Total + the long-handled hoe which provided 80% control of broadleaf weeds. Sencor Plus with either Select Max + Cobra, MaisTer Power, the short-handled hoe or the motorized weeder provided 80-82% control of grasses at 8 WAP.

Results of maize harvest from the cassava/maize intercrop trials:

At Oyo State farm sites, maize populations at harvest from researcher-managed plots were significantly higher than maize populations in farmer-managed plots. Maize population, total number of green maize cobs [unmarketable + marketable], total number of marketable green cobs and income from sale of marketable green cobs was significantly lower in the farmer-managed plots than the researcher-managed plots. Plots in which MaisTer Power was used for post-emergence weed control had the highest maize population. Post-emergence weed control with MaisTer Power, long- and short-

handled hoes resulted in a significant increase in the number of marketable green cobs compared with plots without post-emergence weed control. The number of marketable green cobs from plots treated with pre-emergence herbicides was significantly higher than from the zero pre-emergence herbicide plots. Averaged across post-emergence treatments, marketable green maize cobs from plots treated with Lagon followed by Primextra gave the highest income. Pre- by post-emergence weed control interaction effects on maize population, total number of all cobs (marketable + unmarketable) and marketable cobs were significant. Gardoprim applied pre-emergence plus post-emergence weed control with either the motorized weeder, MaisTer Power or MaisTer 61 WG had the optimum maize population (40,000 plants/ha) at harvest. Plots treated with Lagon + the short-handled hoe and Primextra + MaisTer Power had 98.9% of the target maize population. Plots treated with Lagon alone without post-emergence weed control had 98.1% of the target maize population. Plots that were not sprayed with pre-emergence herbicides but were treated with MaisTer Power as post-emergence herbicide had 97.8% of the target maize population. Income from sale of fresh marketable green maize from the following treatments in a descending order of importance was Lagon + long-handled hoe > Lagon + short-handled hoe > Primextra + long-handled hoe > Primextra + short-handled hoe >Gardoprim + Zero post (without any post-emergence treatment) > Lagon + MaisTer Power > Lagon + MaisTer 61 WG >Lagon + Zero post (without any post-emergence treatment) > Gardoprim + Small Mantis was from 1.82 times to twice the income from sales of marketable green maize from farmer-managed plots.

At Ogun State farm sites, farmer-managed plots had the lowest maize population, total number of all maize cobs (unmarketable + marketable), total number of marketable green cobs and income from the sale of marketable green cobs. Income from the sale of marketable green maize from plots treated with pre-emergence herbicides was 5.1 to 6.3 times higher than the income realized from the sale of marketable green maize from farmer-managed plots. Maize population in farmer-managed plots was significantly lower than the maize population in the researcher-managed plots. Pre- by post-emergence weed control interaction effects on maize population was significant. Plots treated with Primextra + the small Mantis and Primextra + MaisTer Power maintained 90.8 and 90.2% of target maize population respectively. Plots treated with Fierce + short-handled hoe, and Fierce + MaisTer 61 WG maintained 87.8 and 87% of target maize population. In general, all plots with pre-emergence herbicides produced significantly more fresh green cobs (both unmarketable and marketable) and generated more income than the farmer managed plots. Primextra + Small Mantis >Primextra + MaisTer 61 WG >Primextra + short-handled hoe >Primextra + MaisTer Power >Gardoprim + short-handled hoe >Gardoprim + Small Mantis>Primextra + long-handled hoe >Gardoprim + MaisTer Power were the 8 top highest producers of marketable fresh green maize cobs out of 36 combinations of pre- and post-emergence treatments.. Plots treated with Primextra and weeded once with the mechanized rotary weeder generated the highest income from the sale of marketable fresh green maize cobs which was over 500% higher than the income from the sale of green maize cobs from the farmer managed plots. Plots treated with Primextra in combination with either the short-handled hoe, MaisTer Power, MaisTer 61 WG or the long-handled hoe; Gardoprim with either MaisTer Power or the short-handled hoe or Mantis rotary weeder; and Movon with either MaisTer 61 WG or the short-handled hoe generated more income than the other treatment combinations.

At Benue State farm sites, the total number of maize green cobs, marketable green cobs and income from sale of marketable green cobs were significantly lower in farmer managed fields than in research managed fields. Plots treated with Lagon and Gardoprim had the highest number of total green cobs (unmarketable + marketable). Gardoprim followed by Lagon generated the highest income from the sale of marketable green cobs. The interaction of effect of pre- and post-emergence weed control on the total number of marketable green cobs was significant with plots treated with Gardoprim + short-handled hoe followed by Lagon + short-handled hoe, Lagon + MaisTer Power, Lagon + long-handled hoe, Fierce + small Mantis, Gardoprim + small Mantis, Gardoprim + MaisTer Power and Movon + small Mantis as the top 8 highest producers of marketable green cobs. The following 8 treatment combinations - Lagon + short-handled hoe followed by Gardoprim + the short-handled hoe, Lagon + MaisTer Power, Lagon + the long-handled hoe, Gardoprim + MaisTer Power, Fierce + the small Mantis and Movon + MaisTer Power - generated the highest income from sale of marketable green cobs out of 36 different treatment combinations.

At Abia State farm sites, as was observed in Oyo, Ogun and Benue States, maize population, number of green maize cobs and income from the sale of marketable maize cobs were lowest in farmer-managed fields. Although the interaction between pre- and post-emergence treatments was not significant, plots treated with Fierce followed by Movon and hoe weeded once with the long-handled hoe (Fierce + long-handled hoe, Movon + long-handled hoe) produced the highest number of marketable green cobs and generated more income from the sale of marketable green cobs. In term of maize production, these two herbicides combinations could be recommended for maize production in a cassava-maize intercrop.

Result of combined data analysis: Data from Oyo (Derived Savanna), Ogun (Humid Forest) and Benue (Guinea Savanna) farm sites were combined to assess the performance of the pre- and post-emergence weed control on maize productivity. Across the States/agroecological zones, maize population, total number of green (unmarketable and marketable) cobs, total number of marketable cobs and income from farmer-managed plots were significantly lower than from the pre- and post-emergence weed control treatments. Within the researcher-managed plots, the total number of green (unmarketable and marketable) cobs, marketable cobs and also income from sale of marketable cobs of the no-pre-emergence plots were significantly lower than from plots treated with pre-emergence herbicides. Out of 36 pre- and post-emergence treatment combinations, Lagon + short-handled hoe maintained 90.2% of the target maize population across the zones. Averaged across post-emergence treatments, plots treated with Gardoprim Plus Gold followed by Primextra and Lagon generated higher income from the sale of marketable green cobs. Plots treated with the following treatment combinations: Primextra + the short-handled hoe, Lagon + the short-handled hoe, Gardoprim + MaisTer Power, Lagon + the long-handled hoe, Primextra + MaisTer Power and Gardoprim + Zero post (without any post-emergence treatment) were among the top 8 combinations, producing marketable green cobs. Plots treated with Primextra + the short-handled hoe followed by Lagon + the short-handled hoe, Gardoprim + MaisTer Power, Lagon + the long-handled hoe, Gardoprim + the small Mantis, Primextra + MaisTer Power and Movon + MaisTer Power generated higher income from the sale of marketable green cobs than the other treatments.
A cost: benefit analysis of the on-farm trials will be completed when the cassava roots are harvested at 10 months.

Mid-season farmers' evaluation of weed control treatments in four States of Nigeria

The mid-season evaluations were designed to have an independent assessment of the different treatments in the on-farm trials. Experimental design and field layout have already been described above. To assess treated plots, a three-point scale of 'Not Clean', 'Clean', and 'Very Clean' was adopted. Responses from 'Not Clean' were awarded a mark of 1, 'from Clean' were awarded 2, and from 'Very Clean' were awarded 3. Each farmer/respondent assessed a total of 36 treatments in the cassava/maize intercrop trials and 56 treatments in the cassava monocrop at 12 WAP. A farmer-practice plot at each site was included in the evaluation. The scores for each plot in a site were added and a mean was calculated using SPSS stats Package. Plots with scores below the mean were considered poor while those with scores equal to or above the mean were considered good. To get the best treatments, the mean scores of the plots were ranked in descending order. Plots with the highest means were selected and considered the best treatments. A non-parametric tool (Friedman's Test) was used to test the difference among the best performing treatments. For the cassava-maize intercrop fields, a total of 209 respondents participated in the mid-season evaluation; 164 farmers participated in the cassava monocrop fields. Personal characteristics, gender, age and educational qualification of respondents were also captured. The results are presented in two parts: Farmers' evaluation of cassava-maize intercrop and Farmers' evaluation of cassava monocrop.

Results for cassava-maize intercrop

In Abia State farm sites, farmers rated plots treated with Fierce + the short-handled hoe the best followed by Fierce + the small Mantis rotary weeder, No pre-emergence + the long-handled hoe, No pre-emergence + the small Mantis rotary weeder, Gardoprim Plus Gold + Zero post (without any post-emergence treatment) and No pre-emergence + MaisTer 61 WG in that order.

In Benue State farm sites, plots treated with Fierce + MaisTer Power were rated the best in terms of cleanliness followed by Gardoprim Plus Gold + MaisTer Power, Fierce + MaisTer 61 WG, Movon + MaisTer Power, and Gardoprim Plus Gold + the long-handled hoe.

In Ogun State farm sites, plots treated with Movon + the long-handled hoe were rated best followed by Lagon + MaisTer Power, Movon + MaisTer Power, Movon + MaisTer 61 WG, Primextra Gold + MaisTer Power and Primextra Gold + MaisTer 61 WG.

In Oyo State farm sites, farmers rated plots treated with Primextra Gold + MaisTer Power the best followed by Movon + MaisTer 61 WG, Movon + MaisTer Power, Lagon + MaisTer Power, Fierce + MaisTer Power and Primextra Gold + MaisTer 61 WG in that order .

The results across the four States indicated that farmers rated plots treated with Fierce + MaisTer Power as the cleanest followed by Movon + MaisTer Power, Primextra + MaisTer Power, Lagon + MaisTer Power, Fierce + MaisTer 61 WG, Movon + MaisTer 61 WG and Gardoprim + MaisTer Power. A non-parametric test (Friedman's Test) was carried out to investigate if there was any statistical difference among the top best seven treatments (i.e., Fierce + Maister Power, Movon + MaisTer Power, Primextra + MaisTer Power, Lagon + MaisTer Power, Fierce + MaisTer 61 WG, Movon + MaisTer 61 WG and Gardoprim + MaisTer Power). The result shows that there was no significant difference among the treatments implying that any of these treatments could be recommended to farmers.

Results for cassava monocrop

In Abia State farm sites, respondents rated plots treated with Merlin Total + Zero Post (without any post-emergence herbicides) as the best, followed by Sencor Plus + MaisTer Power, Merlin Total + MaisTer Power, Merlin Total + Select Max and Cobra, and Primextra Gold + Select Max and Cobra in that order.

In Benue State farm sites, farmers rated plots treated with Gardoprim Plus Gold + Fusilade + Cobra as best followed by Merlin Total + Select Max and Cobra, Movon + Fusilade + Cobra, Sencor Plus + Select Max and Cobra, Primextra Gold + Select Max and Cobra, and Primextra Gold + Fusilade + Cobra in that order.

In Ogun State farm sites, farmers rated plots treated with Merlin Total + Fusilade and Cobra as the best in terms of cleanliness followed by Merlin Total + Maister Power, Movon + MaisTer Power, Merlin Total + Glyphosate, Fierce + Glyphosate, and Primextra Gold + Glyphosate in that order.

In Oyo State farm sites, farmers rated plots treated with Fierce + Select Max and Cobra as the best followed by Merlin Total + the small Mantis rotary weeder, Sencor Plus + the short-handled hoe, Sencor Plus + Select Max and Cobra, Fierce + MaisTer Power, and Sencor Plus + Glyphosate in that order.

The rating across Abia, Benue, Ogun, and Oyo farm sites revealed that plots treated with Merlin Total + Fusilade and Cobra got the highest rating in terms of cleanliness of fields followed by Fierce + Select Max and Cobra, Fierce + MaisTer Power, Merlin Total + Select Max and Cobra, Primextra Gold + Select Max and Cobra, Sencor Plus + MaisTer Power and Sencor Plus + Select Max and Cobra in that order. A non-parametric test (Friedman's Test) was carried out to investigate if there was any statistical difference among the top best seven treatments (i.e., Merlin Total + Fusilade and Cobra, Fierce + Select Max and Cobra, Fierce + MaisTer Power, Merlin Total + Select Max and Cobra, Primextra Gold + Select Max and Cobra, Sencor Plus + MaisTer Power and Sencor Plus + Select Max and Cobra. The result shows that there was no significant difference among the treatments implying that any of these treatments could be recommended to farmers.

Objective 4

This Objective seeks to involve farmers and other stakeholders in the research to develop improved weed management practices in cassava. It also aims to empower extension services, primarily the ADPs but also NGOs, agro-dealers, and spray service providers, to provide farmers with the knowledge they need to improve weed management practices.

Key milestone: 150 on-farm field demonstrations and farmer field days are organized in the three project areas.
Output: 150 on-farm field demonstrations and farmer field days are organized in the three project areas. (To organize farm demonstrations and farmer field days during Years 3-5 for farmers (women and men) and extension workers)

During the year under review, 58 on-farm trials were established across four States— Abia, Benue, Ogun and Oyo. Although the project document specified that 15 on-farm trials be established in the year under review, the Project leadership proposed that more sites be covered to sustain momentum and reach more farmers with solutions for weed control. The 58 on-farm trials comprised 33 cassava monocrop trials and 25 cassava-maize intercrop trials. Out of the 58 on-farm trials, 8 were mechanical weeding trials established as cassava monocrop. Farmer field days were conducted in the cassava-maize intercrop on-farm trials at 10-12 WAP. The timing of the field days was designed to target maize harvest so farmers could observe the impact of good weed control on maize (especially yield) and also cassava growth. During the field days, farmers and other actors were mobilized to the event to show and tell. Participants that attended the field days were women and men farmers, local extension agents from the four State Agricultural Development Programs and other extension service providers, including Spray Service Providers. Other participants included the Local and State Government officials, the private sector (Monsanto and Syngenta), farmers' and women's groups. The field days provided a forum for project implementers to educate farmers on herbicide application and safety. Farmers also participated in the mid-season evaluation of each of the plots. Through the field days and other project related activities, the Project reached 7121 persons comprising 4892 males and 2229 females. Farmers were also given the opportunity to evaluate the trials.

Key milestone: State-based extension services (ADPs), Weed Control Business Groups and other locally identified extension services provide farmers with the knowledge they need to improve weed management.
Output 1: Weed Control Business Groups (women and men) are functional to work as extension partners for 30,000 farmers in the 11 district zones of the on-farm trials by Year 4.

Four State-based Agricultural Development Programs (ADPs) in Abia, Benue, Ogun and Oyo were engaged in Year 1 of the project with the signing of four memoranda of understanding. This paved the way for collaboration between the project coordination unit and the ADPs. In 2016, 34 ADP extension agents were involved in the management of the on-farm trials. In addition, four extension service providers from the Justice Development and Peace Movement (JDPM) of Oyo (Oyo State) and Abeokuta (Ogun State) were involved. The JDPM of Oyo is working with 400 farmers. Kolping International (an NGO) was also engaged in Abia to help in dissemination efforts. Kolping International has about 400 farmers working with them in the rural areas of Abia State. Working with these partners, the project identified and mobilized 706 Spray Service Providers, 638 males and 68 females across the 58 on-farm trial sites. A select number of the Spray Service Providers also participated in the 2016 training on Herbicide Application and Use. This training was organized by IITA in collaboration with Bayer AG. The strategy was for them to go back to their various groups and pass on the knowledge to colleagues. In 2017, ahead of the planting season, additional trainings targeting the Spray Service Providers are planned.

Training of extension service providers

Output 2: A 5-day ToT course for ADP extension agents is successfully implemented by Year 3.

A five-day ToT for extension agents in four ADPs of Abia, Benue, Ogun and Oyo was conducted in April 2016. The training was facilitated by IITA resource persons with a specialized background and experts from the University of Ibadan, University of Agriculture, Makurdi, National Root Crops Research Institute, Umudike, and a consultant training expert, Hannah Anighoro. Bayer AG also supported the training with equipment, materials and staff.

Key Milestone: A community assessment and 22 focus group discussions (FGDs) are conducted in 11 local governments (1 for women and 1 for men) by Year 2.
Output: A community assessment and 22 FGDs are conducted in 11 local governments (1 for women and 1 for men) by Year 2.

In 2015, the Project conducted a community assessment via FGDs involving 196 women, men and young people using qualitative methods to better understand the level of knowledge, attitudes, and practices (KAP) of farmers. On the advice of the Project Steering Committee, a survey was conducted in 2016 to build on the findings of the FGDs to have a quantitative understanding on the level of herbicides use across the States, farm sizes and other aspects of cassava production related to weed control. The survey was conducted across the four States involving 895 respondents. The result of this survey is being analyzed and will be made available before the Annual Work Planning Meeting in March 2017.

Knowledge, Attitudes, and Practices (KAP) study in cassava weed management

Key milestone: Effective print material is produced (photo guide, pocket guide, posters) and distributed to farmers and other stakeholders via on-farm demonstrations and training.
Output 1: Effective print material is produced (photo guide, pocket guide, posters) and distributed to farmers and other stakeholders via on-farm demonstrations and training.

Following the Training Needs Assessment conducted in 2015, there was the need to empower researchers and extension partners with tools to help them in weed identification. As a result, the Project revised the second edition of the Handbook of West African Weeds with the addition of 52 additional new weed species, and 53 weed seedlings. Two thousand copies of the publication have been published and are being disseminated to partners. Six posters have been developed and displayed during field days. One of the posters won the IITA award as one of the best posters published in 2016 and was covered in the Cassava Matters Newsletter. The Project team also published a fact sheet entitled Facts about cassava production worldwide and the challenges in weed management that offer opportunities for herbicides companies. The aim of the publication was to give the chemical industry facts about the market of cassava-based herbicides in Nigeria in particular and Africa at large.
The Project also developed two flyers—a Project brief and Unleashing the Yield Potential of Cassava in Sub-Saharan Africa through Sustainable Weed Management Technologies. These flyers were distributed to farmers during field days. More flyers are planned in 2017. Signposts were also made on each of the on-farm trial sites and the plots were clearly labeled to facilitate learning.

Output 2: One curriculum for Training of Trainers for ADP extension workers is developed

Following the Training Needs Assessment conducted in 2015, a training manual was developed covering gender and social issues, group formation and dynamics, report writing, computer science, adult learning, effective meeting, principles of participation and communication. These areas were necessary to help the extension service providers to organize sustainable groups at the community level for technology transfer. A second curriculum is in process and will incorporate findings and recommendations from the project scientists in the first quarter of 2017, ahead of the planting season.

Output 3: 100 trainers and 3000 training participant guides are available in Year 3.

100 training manuals were developed and shared to extension service providers on gender and social issues, group formation and dynamics, report writing, computer science, adult learning, effective meetings, principles of participation and communication. Participants' guides are planned in the first quarter of 2017 ahead of the planting season. The participants' guide (The ABC of Cassava Production) is currently being reviewed by the research team and will contain the validated findings from the project.

Key milestone: Research findings are translated in content and language and packaged in different formats ready for dissemination to farmers and different stakeholders and uploaded on the web by Year 3.

Output 1: Research findings are translated in content and language and packaged in different formats ready for dissemination to farmers and different stakeholders and uploaded on the web by Year 3.

A multimedia approach has been adopted in the translation of research findings to different stakeholders. Consequently, five newsletters were produced in 2016 and uploaded on the websites. The newsletters reached about 3005 persons. The content of the newsletters was packaged in a language that is easily understood by the non-research community. The project team also joined forces with other sister projects—the African Cassava Agronomy Initiative and BASICS—to have a common newsletter and website known as www.cassavamatters.org. Research activities and progress were also uploaded on the website and also widely distributed to newspapers, television and radio. In all, 12 press releases were made and shared with more than 200 journalists across the world. Besides, a proactive PR- approach was adopted right from the beginning of the project, and the project remained active on social media, Twitter, Facebook, LinkedIn, etc. Through the social media, we have been able to reach 108,072 persons who are now aware of the project. The project's WhatsApp group known as 'Cassavamatters' is fully subscribed with 256 persons and has remained an interactive and effective platform of engagement for cassava stakeholders. The project's work was published extensively in several newspapers including an article in the UK-based journal Outlooks on Pest Management.

Output 2: The benefits of improved weed technologies are elaborated and produced via a series of 3 radio spots (increased yield, reduced labor, improved health).

Three radio spots are planned for 2017, ahead of the planting season. Already, a meeting was held between two experts, one from the Department of Mass Communication at the Ibadan Polytechnic and a freelance radio broadcaster, Ibrahim Azeez, and the Project's Communication and Knowledge Exchange Expert with the view to developing a script for the jingle on the benefits of improved weed management technologies.

Output 3: An educational on-farm trial video documentation on integrated weed management is completed and ready for distribution in Year 4

During the period 2016, two videos were developed in response to the Knowledge Attitudes and Practices study highlighting what different approaches the Project is working on to tackle the problem of weed control in cassava. The videos were subsequently shared on YouTube in order to get wide publicity and also on the website (www.cassavaweed.org). The second video was developed in conjunction with Channels Television (www.channelstv.com) which is viewed by about 1.2 billion people across the world (GeoPoll, 2017). New videos are planned as researchers validate their research findings on-farm in 2017 after harvest.

Objective 5

This Objective seeks to ensure that the project creates impact through good governance, and that there are effective management strategies for result, which will eventually lead to handover to national partners.

Key Milestone: One workshop organized

The 2016 Annual Review and Work Planning Meeting was successfully organized with a wide range of stakeholders on 25-26 April, 2016 at IITA, Ibadan. A total of 69 participants were in attendance from the Gates Foundation, partner institutions (FUNAAB, NRCRI, UAM), Government Regulatory Agencies (SON, NESREA, NAFDAC), Purdue University, Chemical Company (Bayer AG), Federal Ministry of Agriculture and Rural Development (FMARD), cassava processors, National Cassava Growers Association, State ADPs, farmers, and IITA project staff and community. The achievements of the Project in Year 2 (2015), and work plan for the implementation of activities in Year 3 (2016) were discussed in detail and finalized for presentation to the Steering Committee (SC) of the Project for approval.

2016 Annual Review and Work Planning meeting of the IITA Cassava Weed Management Project

Key Milestone: Steering Committee meeting held.

The third meeting of the Project's SC and its Sub-Committees were held on the IITA campus, Ibadan, 28 -29 April, 2016. Members of the SC Sub-Committee for Herbicides and Herbicides Safe Usage were also in attendance as resource persons. On receipt of information that the SC Chair (Dr Julius C. Okonkwo, Executive Director of NRCRI), would be unavoidably absent, it was agreed to have Prof. John Ayoade (Deputy Vice Chancellor, Federal University of Agriculture, Makurdi) preside over the meeting as he has been consistent in attending the SC meetings since the Project's inception. The SC approved the 2016 workplan and formulated nine resolutions/recommendations for ensuring the efficient and effective implementation of the project in Year 3. A copy of the recommendations signed by the Acting SC Chair was distributed to the members of the SC. A field trip was also organized for the SC and the Sub-Committee members on Day 2 to one of the Project's implementation sites at IITA for a demonstration of the mechanical weeding of cassava fields.

Members of the Steering Committee of the IITA Cassava Weed Management Project

Output 2: The project's website is up

The Project's website (http://www.cassavaweed.org) which became operational in 2014 continues to increase the visibility and good image of the Project and promotes knowledge sharing among cassava stakeholders. Project accounts on social media platforms such as Facebook (https://www.facebook.com/Sustainablecassavasystems), Twitter (https://twitter.com/Cassavaweedmgt), Slideshare (http://www.slideshare.net/CassavaWeed14), and LinkedIn were all operational in 2016. Information on the website is regularly updated. In addition, the Cassava Weed Management Project collaborated with two other projects funded by Bill & Melinda Gates Foundation (ACAI and BASICS) to launch the Cassavamatters website (http://www.cassavamatters.org), Cassavamatters newsletter and Cassavamatters Whatsapp Group in June 2016. This complementarity and synergy promoted knowledge-sharing and increased collaboration among the projects. Five issues of the now bimonthly Cassavamatters Newsletters have been produced. The fully subscribed Whatsapp group with membership of 256 provides a platform for various actors in the cassava value chain to link with each other thus promoting interactions among key stakeholders. The project has never had any bad press coverage since its inception.

The project also developed 12 press releases and shared to over 200 journalists across the world. These press releases were covered and picked up by online and traditional media. The farmers' field days were covered in the radio and other activities of the project were also reported on the television. Through the social and traditional media, the project was able to reach 115193 persons.

PLATFORMS	TOTAL PERSONS REACHED
Flickr	193
LinkedIn	1565
Facebook	1805
Twitter	84601
Pinterest	5725
Slideshare	8103
Website	1851
Whatsapp	256
Newspapers – (Journalists)	208
YouTube	760
Cassava matters newsletter	3005
Total	**108072**
Total farmers reached through onfarm and field activities	**7121**
Grand total	**115193**

Key Milestone: Project Management Trainings held.

Output 3: The capacity for NRCRI to manage complex projects, such as this one, will be enhanced through direct training on project management provided by the PC, PM, Project Management Team, and IITA's Management Team, beginning in Year 2.

In 2016, the Project continued to facilitate capacity building of the collaborating partners by 'learning-by-doing'. A week-long working visit (14-18 March, 2016) was organized for the NRCRI Project coordinator/AEZ scientist (Dr Adeyemi Olojede) at IITA to enable him have learning-by-doing sessions with the then Head, Project Administration Office, all the units in the IITA Project Administration Office (Documentation, Project Resource Management, Contract compliance office, Technical and financial office, etc.), IITA Human Resource Services, and the Project Management Team of Cassava Weed Management Project.

In addition, hands-on training on Project Administrative and Financial Management was also extended (11-15 January, 2016) to 15 FUNAAB and 7 UAM Project team members at their respective universities by the IITA Project Accountant and a representative from the IITA Project Administration Office to ensure that these partner institutions are conversant with the Gates Foundation and IITA rules and procedures. The training approach used include slide presentations, Interactive and hands-on sessions, use of Case Studies and clarity of concepts of technical terminologies as these apply to Gates Foundation and IITA rules and procedures. The training was also aimed at giving the facilitators the opportunity to assess how far the previous trainings have had an impact on their job performance. Project partners from NRCRI, FUNAAB and UAM who were present at IITA during the Project Joint Quarterly Review Meeting (JQRM) (17-18 February 2016) were trained on the use of Social Media as a resource and effective tool in project implementation.

A Training Workshop on Herbicide Action on Weeds and Crops was organized 1-3 March, 2016 for 41 participants (27 males and 14 female comprising project staff of IITA, NRCRI, FUNAAB, UAM, ADPs, and Spray Service Providers) to upgrade their technical skills in agronomy and weed science.

A Training of Trainers supported by Bayer

The course content includes the characteristics of the essential aspects of the major herbicide sites of action, description of the herbicide mode of action, process, and critical steps that influence efficacy as well the current and practical understanding of herbicide resistance in crops and weeds. Four resource persons (Prof. Stephen Weller of Purdue University, Prof. Michael Owen, Iowa State University, Prof. S. Lagoke, FUNAAB, Abeokuta, Nigeria; and Prof. Friday Ekeleme, Principal Investigator, CWMP/ IITA, Ibadan) facilitated the training.

A Combined Data Analysis Workshop (21-22 March 2016) was also organized for project partners to ensure harmonization in data capturing and analysis across the partner locations.
A Training of Trainers Workshop on herbicide use and their safety was organized 18- 20 April, 2016 for lead farmers, ADP Staff, Extension Agents and Spray Service Providers [37 participants comprising 29 males and 8 females] to enable the lead farmers, ADP staff, Extension Agents and Spray Service Providers to support training of farmers in their respective locations where the project is working, thereby disseminating information of new knowledge on weed control. Following this, another training workshop on application techniques and the safe use of pesticides was also conducted (21-23 April, 2016) for staff of project collaborating institutions [research centers (IITA, NRCRI), Regulatory Agencies (SON, NAFDAC, NESREA), Universities (FUNAAB, MOUAU, UI, UAM), NGOs (KOLPING Nigeria, JDPM Abeokuta) and State ADPs (OGADP, ABIA ADP, BENADP, OYO ADP) and Government agencies (FMARD and Ministry of Environment)]. A total of 89 participants (76 males and 13 females) were trained.

Also, a one-day training workshop on the use of electronic devices (tablets) to capture data in the laboratory and field was organized on 28 June 2016 during the sixth JQRM at UAM for the project team members of partner institutions.

Meetings

Following the first meeting (2 December, 2015) among the IITA Project Management Team, National Root Crops Research Institute (NRCRI), and IITA Senior Management for the transition of leadership of the project to NRCRI, another meeting was held on16 February, 2016 at IITA involving IITA Management and the Project Management team as well as the Executive Director, Director of Planning and Project Coordinator of NRCRI) with the objective of reviewing the progress made after the first transition meeting and the Capacity Development Plan prepared by the IITA Capacity Development Office (CDO), and the Standard Operating Procedure prepared by IITA Project Management Office. The IITA Project Administration Office (PAO), Capacity Development Office and IITA M&E consultant on the project made presentations on the Administrative, Capacity Development and M&E transition plans, respectively. The IITA DDG, P4D and the Project Leader reiterated IITA's commitment to hand over the project leadership to NRCRI as already designed in the Project document and commended the team spirit exhibited by partners and urged everyone to sustain the tempo.

Subsequently at NRCRI, a joint interactive meeting and training session between the IITA project team, NRCRI project team members, IITA-CDO and IITA-PAO was organized from 8 to 9 March, 2016.
The objective was to facilitate further the process of the leadership transition to NRCRI to ensure that necessary frameworks are in place while also addressing the specific needs of the partners (UAM and FUNAAB) who will be working with NRCRI. The team from IITA had interactions with the NRCRI's

Executive Director and Director of Administration on possible areas to build capacity to ensure efficient implementation of the project and readiness for seamless operation after the hand-over, especially in establishing the proposed Grant & Contract office in NRCRI. The IITA team also trained the NRCRI team on the requirements for setting up and running a Grant and Contracts office for donor- funded projects.

The institute's Executive Director who doubles as the SC chair was also supported to attend the World Congress for Root and Tuber Crops in Nanning, China, in January 2016 to offer him the opportunity to be in touch with current trends in global root and tuber crops research and development.

Four Joint Quarterly Review Meetings (JQRM) for project staff at IITA and partner institutions were held in 2016 as follows: IITA (17-18 February), UAM (27-28 June), FUNAAB (27 September) and NRCRI (10 December) to take stock of the progress of project implementation with a view to addressing any challenges to implementation.

The project hosted the 4th, 5th and 6th Nigerian Engineers and Fabricators' brainstorming sessions on 10 -11 and 21-22 October, 2016 and 19-20 November, 2016. The brainstorming sessions were organized to produce prototype weeders for smallholder cassava farms, adapt/modify and test both the introduced Rotary and Wiggle weeders for use by smallholder farmers as well as training to build local capacity for production and maintenance.

Visits to the private sector and other key stakeholders

As part of efforts to facilitate the registration process of proven herbicides, the Project Management Team visited Syngenta and held discussions on the registration of their products. They also met with a team from Monsanto and held discussions on the continued availability in Nigeria of their product which was tested in the project. In addition, Professor Steven Weller of Purdue University was contacted to hold discussion with Valent on the Project's behalf regarding product registration in Nigeria. Furthermore, the Project Management Team is visiting Bayer AG in Germany from 13 to 17 February to discuss registration of their products tested in the Project and to seek increased collaboration in the areas of training and weed control in other staple crops in Africa. The Project Team will visit FMARD, NAFDAC, SON, NESREA, Partner Institutions and other key stakeholders such as CropLife, FAO, IFAD, etc., to discuss the preparation of the investment project in Year 4 to extend the Project to an additional 20 cassava producing States in Nigeria.

Key Milestone: M&E of Project is conducted.

Output 4: Internal monitoring of the project is conducted to ensure timely adjustments in strategies and tactics to realize the desired outputs of the Project.

The M&E baseline survey conducted at project locations from 21 to 22 October (UAM), 26 to 30 October (UAM), 2 to 6 November, 2015 (FUNAAB) and which was at the time of submission of the 2015 annual report undergoing in-house review at IITA, was completed in 2016.

The M&E consultant on the Project together with an M&E team conducted monitoring visits to all trial sites of IITA and partners institutions from 17 to 25 October, 2016.

The M&E focal persons and project administrators from the partner institutions were also trained from 26 to 28 October, 2016 at NRCRI on M&E principles and applications.