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Cassava Weed Management Project at Work

2015 Progress Report

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2015 Progress Report

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Content

Acronyms

ADP	Agricultural Development Programme
ALS	Acetolactate Synthase
EDADP	Edo State Agricultural Development Programme
FMARD	Federal Ministry of Agriculture and Rural Development
FUNAAB	Federal University of Agriculture Abeokuta
GIT	Good in Transit
GPS	Global Positioning System
KAP	Knowledge, Attitude and Practices
LGA	Local Government Area
NAFDAC	National Agency for Food and Drug Administration and Control
NCGA	Nigeria Cassava Growers Association
NESREA	National Environmental Standards and Regulations Enforcement Agency
NCRI	National Cereal Research Institute
NRCRI	National Root Crops Research Institute
PAO	Project Administration Office
PC	Project Coordinator
PM	Project Management
PI	Principal Investigator
SABs	South African Bureau of Standards
SAS	Statistical Analysis Software
SC	Steering Committee
SWOT	Strength, Weakness, Opportunities and Threats
TNA	Training Needs Assessment
UAM	University of Agriculture Makurdi
WAP	Weeks after planting
WAT	Weeks after treatment
WHO	World Health Organization
WSC	Weed Science Center

Background

This report presents the achievement and progress made by the Cassava Weed Management Project (Sustainable Weed Management Technologies for Cassava Systems in Nigeria) in 2015 towards tackling the menace of weeds in cassava farming systems in Nigeria. Specifically, the report captures all aspects of agronomy, mechanical weeding options, and the use of environmentally friendly herbicides. It also tracks the efforts made in communication and the preliminary extension set ups being pursed to ensure the sustainability of the project. Partnerships and capacity building of national partners are key ingredients that define the success of any project, and the Cassava Weed Management Project has put these components as part of its core values. This progress report covers the milestones under the four Objectives of the project for year 2.

About the Cassava Weed Management Project

The Cassava Weed Management Project 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 consequently increase cassava productivity using improved and integrated approaches to weed management. 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.

Objective 1: Develop appropriate agronomic practices that increase cassava productivity, and reduce losses from weed competition and drudgery for women and children.

General aspects and changes

With the multiplication of field trials in 2015 (double the number of agronomy (density) trials, and additional weeding frequency, and mechanical weeding trials), it was considered unfeasible to determine the weeds by species in all trials. Weed identification for one sampling in one density trial takes about 4 days. This required 16 working days for the density trials in 2015 every 4 weeks. Due to this high labor demand, it was decided to change the resolution of weed determination in the weeding frequency and the mechanical weeding trials. In the latter two trials, the weeds are separated into grasses (Poaceae), sedges (Cyperaceae), broadleaves of erect or prostrate growth habit, climbers (any winding or otherwise climbing species*), Chromolaena odorata*, species of the bush or natural fallow growth (meaning species sprouting from plant parts below ground other than grasses and not germinating from seeds), others (such as oil palm and tree seedlings, as well as ferns), and the most problematic weed at the specific site. The latter was *Tithonia diversifolia* in the IITA sites. It could be any other species such as *Imperata cylindrica* or *Mimosa spp*. in other sites. The number of the individuals per category was counted and the total sample was dried to constant mass and weighed for weed biomass dry matter determination.

In 2014, we attempted to estimate canopy cover by taking vertical digital photographs and converting the images into the proportion of the image covered by canopy. This approach had its own limitations. To overcome the limitations of use of cameras and add scientific rigor in 2015, a set of ceptometers was acquired. Ceptometers measure the photosynthetically active radiation (PAR) and produce data closely related to the production potential of a crop or weeds at various levels in a stand of cassava. The ceptometers permit labeling plot by plot or sub-plot by sub-plot

L-R: Lawrence Kent (Bill &Melinda Gates Foundation), Stefan Hauser (IITA), Charlie Riches (Weed Expert) during a visit to the cassava agronomy trials in Ibadan and thus are less susceptible to errors that could be made by technicians in the field. Taking readings takes about as long as taking photos yet the conversion is no longer required and thus the data are immediately available and of higher importance. Training courses on the ceptometer use and data handling were conducted with all partners.

Key Milestone 1: Data on single factor effects and interactions on weed abundance and biomass and cassava yields.

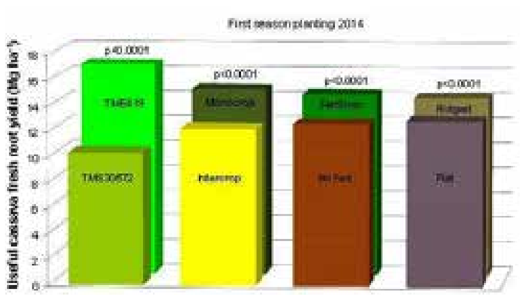
Output 3. Agronomic trials to optimize productivity, while minimizing weed stress, are conducted in three agro-ecologies.

The 2014 first and second season plantings of the 5-factorial density trials harvested in 2015 produced partially contrasting results on weed biomass and cassava root yields. Cassava yield is expressed as “useful fresh root yield” – this means only roots that are suitable for consumption or processing (small-scale and industrial) are considered. This avoids declaring rotten, lignified roots or roots not fit for consumption or processing as yield. The useful cassava fresh root yield was significantly affected by site and season.

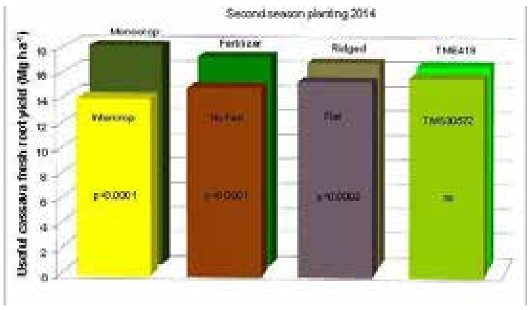
Cassava root yields were on average higher in the 2nd season planting (15.93 Mg/ha) than in the 1st season planting (13.46 Mg/ha). The differences within site between seasons were highly variable with the trials in Makurdi producing the highest yields in the 2nd season yet the lowest in the first season. At Umudike (NRCRI), Abeokuta (FUNAAB) and Anyigba (UAM) differences between seasons were small. Across sites, the factors: variety, cropping system, fertilizer application, and tillage were all highly significant in the first and second season with the exception of variety in the second seasons. Root yields were most affected by the cassava variety. Results of the second season planting were different with the effect of cassava variety on root yield being insignificant, and cropping system i.e. cassava monocrop versus cassava intercropped with maize having the largest positive impact on yield.

Planting density

In both seasons the actual attained plant densities remained below the intended plant densities. Across sites, the attained density was 77.6 % in the first and 75.9 % in the second season planting.



Effect of variety, cropping system, fertilizer application and tillage on cassava fresh root yield across seven sites in Nigeria. 2014–2015 first season values above columns indicate the levels of significance separating the mean factor.



Effect of cropping system, fertilizer application, tillage, and variety on useful cassava fresh root yield across eight sites in Nigeria. 2014–2015 second season planting. P values in columns indicate the levels of significance separating the means of each factor. ns – not significant

The discrepancy between intended and attained density increased as we increased intended density thus partially obliterating the objective of increased cassava densities to control weeds. The pattern was the same in the second season with a slightly lower level. Relative to the lowest density the increase in plant density was 80.2 % to the highest density in the first season and 84.2 % in the second season. Thus the higher densities did not really reflect the intended increase.

Cassava root yields were not affected by the plant densities in the first season, yet in the second season yields were significantly higher in the 20000 plants/ha (2 plants/m^2) treatments than all others. A general trend towards higher yields at higher densities is confirmed ($r^2 = 0.8058$) with the second season data.

Conclusion and Recommendations

The agronomy trials (also called density trials) produced results indicating that first and second season planted cassava has strongly different responses to agronomic measures to control weeds and increase root yields. As such the two seasons need to be considered separately. For first season planting, we can maintain the recommendation of (1) 12500 plants/ha; (2) cassava variety TME 419, (3) ridging, and (4) fertilizer application. Intercropping maize in the first season had a generally negligible effect on cassava root yields and can thus be recommended where weed control would not interfere with the maize. The first two recommendations are relatively cost neutral and thus pose no risk. The third and fourth recommendations require labor and capital investment, thus bear a risk. Neither ridging nor fertilizer application had a generally positive effect on yields thus need to be considered as site specific interventions. For second season planting, intercropping with maize had a generally strong negative effect on cassava yields and cannot be recommended. Second season planting as such is strongly recommended due to the generally higher cassava root yields attained (unless sites are prone to cattle damage during the dry season). Considering the potential of fetching higher prices for raw roots at specific phases, there may be a good opportunity in researching further the potential of spreading planting and harvesting time. Unlike in first season plantings we can recommend (1) fertilizer application and (2) ridging, while variety choice had no effect and thus either TME 419 or TMS 30572 can be

Good weed control unleashes the potential of cassava planted. The plant density should not be less than 12500/ha. Problematic with second season planting is the timing of weeding as the recommencing rains cannot be scheduled, and farmers need to weed according to rainfall and weed growth. It appears that it will be a major advantage to determine critical weed biomass or cover levels as from which discernible negative effects on root yields and labor requirements establish. Such weed biomass or cover levels or thresholds would need to be related to weed species or type, cover, weed heights or other easily and visually assessable features. It is recommended to assess the value of a simple decision support tool for farmers that would advise on whether to weed or to wait (Weed or wait®). In addition we observed that specific weeds such as *Tithonia diversifolia* grow much faster than most of the other more common weeds. Damages through such exceptional weeds are often underestimated as they are (at least in the beginning) restricted to smaller areas. However, these weeds will not be successfully controlled with the conventional approaches and timing. In such situations, a species specific decision support tool "Weed or wait S&Sp® (Site and species specific) would be able to advise on controlling specific problem weeds independently of the general weed composition.

Key Milestone 2: New and improved manual and powered mechanical weeding tools and machines attaining reduced weeding labor.

Mechanical weeding

Manual hand hoe weeding and herbicide use could be supplemented by mechanical weeding options. Such options should be labor saving, less capital intensive and environmentally sound. Three motorized and four hand operated tools were tested in a factorial trial with the tillage (ridged versus flat) and the gender of the implement operator as additional factors. The best agronomic practice identified in the agronomy trials through the parameters: cassava root yield and weed biomass were used to plant the respective factor combinations. This was in 7 out of 8 sites at a cassava plant density of 12500 plants/ha, variety TME 419, tillage (ridged and flat), monocrop and fertilizer application. In one site the density was 10000 plants/ha; all other factors were the same as in the other sites. Weeding was conducted as in all other trials at 4, 8, 12 and 24 WAP. Labor time, fuel consumption, and any other aspect of implement use were recorded. Treatment plots were allocated to male and female operators to be able to determine if there were gender related issues with the use of the implements. A detailed description of the weeding implements was provided by Engr. Thierno Diallo, including the modifications that were made to adjust the implements to the requirements of cassava.

Weed biomass was not affected by the implement used to weed, and the gender of the operators did not interact with any of the factors.

At FUNAAB, there was a difference among implements in the time required to weed with the spike weeder being most demanding and hand hoe and the Mantis machine being the fastest. This was similar to the situation at Ibadan. The factor with the largest impact on weeding time was tillage with significantly less time used in ridged plots at Ibadan and about 34 % more time required on flat soil than in ridged soil at FUNAAB. Gender did not significantly affect time required to weed at the 4 and 8 WAP weeding yet female operators took more time at the 12 WAP weeding at Ibadan and about 35% more in total weeding time at FUNAAB. There were no significant differences between the time required to weed using different implements, yet the

Engineers modifying the motorized weeders

one implement with a visible larger time requirement was the spike weeder. The same implement had as well the highest amount of weed biomass and as such appears the least suitable to conduct effective and time efficient weeding. It was removed for the second season trials.

At NRCRI site, female operators required less time (101 minutes) to weed than male operators (124 minutes) ($p<0.0009$). On ridged land, more time was spent (127 minutes) to weed than on flat land (98 minutes) ($p<0.0001$), and there was an effect of the implement used. Farmer practice (hand hoe) weeding took longer (130 minutes) than using either of the Mantis machines (93 minutes) ($p< 0.0056$). However, there was an interesting (albeit not significant) differentiation between male and female operators with females taking about the same amount of time to weed a plot irrespective of the implement they were using, while males took considerably longer time to weed with the hand hoe (157 minutes for males versus 104 for females). Only use of the Mantis machines resulted in similar weeding times of males and females.

At UAM site, more time (60 minutes) was required to weed a plot on flat land than on ridged land (43 minutes). Female operators and male operators were similarly taking long to weed (58 minutes for females and 54 minutes for males). Weeding with the small Mantis machine (39 minutes) and using the hand hoe (44 minutes) were the fastest implements. Brush cutter (85 minutes) and spike weeder (76 minutes) were the slowest implements. Gender differences in weeding time were pronounced when using the large Mantis, the cone weeder and the hand hoe with females requiring 25 – 33 % more time than males.

Conclusion and recommendation on mechanical weeding trials

The mechanical weeding trials, though preliminary, show good results and have opened the opportunity to use a large variety of implements which produce very similar results in weed control and labor time. The Mantis machines appear the most suitable powered implements with the small machine having a slight advantage over the large machine. Although the current data show that the farmers' practice with the hand hoe is the least time-consuming method and controls weeds best, we need to consider that all those who tested the machines were more accustomed to the hand hoe. This gives the hand hoe approach an advantage over the other implements. The Mantis machines appear the most suitable powered implements with the smaller machine having a slight advantage over the bigger machine. With more regular use of the best suited and appreciated implements, the time required to weed will be reduced and the quality of weeding will be improved, i.e., the weed biomass will be lower with every consecutive weeding.

Key Milestone 3: Data on cassava yield response to reduced weeding under best agronomic practices

Output 4: Data on cassava yield response to reduced weeding under best agronomic practices available.

Weeding frequency trials

None of the weeding frequency trials has been harvested for yield data. Weed biomass data for Moniya and Ido sites of Oyo State of the first season trial is presented. The trial had 24 treatments including an un-weeded and a manually kept weed free control. Three weeding approaches were compared: The common manual hand hoe approach at 2, 3 or 4 weedings with all possible combinations of skipping versus conducting the weeding. This resulted in 11 treatments or 12 if the un-weeded control is considered. The second approach was pre–emergence herbicide application with follow up skipped or hand hoe weeding. Here the question to be answered was: "how many weedings can be skipped after pre-emergence herbicide

The motorized mechanical weeder on the field application, thus three treatments were implemented. The third approach was application of post-emergence herbicides to determine if manual hand hoe weeding can be replaced by one or two herbicide applications. The working hypothesis was that a post-emergence herbicide application replaces weeding at the same time, and should at least replace the following weeding. To establish how many weedings can be skipped, a single application was followed by no weeding and weeding at the last and the two last prescribed dates. More permutations are possible yet would inflate the trial and increase costs. Therefore the herbicide application was placed where it is assumed to be most efficient and effective. In addition to the treatments, a 'farmer practice' treatment was established in which the timing and the tools were determined by a collaborating farmer. Farmers chose the manual hand hoe as tool, weeded three times and started weeding later than 4 WAP.

The total cumulative weed biomass was used as an indicator of the effectiveness of the weeding approaches. All data of the individual weed samplings collected except the yield data. Preliminary results showed that with the manual hand hoe approach, cumulative weed biomass across sites ranged from 62.9 to 181.0 g m-2 or 0.629 to 1.81 Mg ha^{-1}. The lowest weed biomass amount was recovered in the treatment manually weeded four times. Weeding three times resulted in 67.3 to 112.5 g m^{-2} weed biomass and weeding twice gave weed biomass of 107.6 to 181.0 g m^{-2}. Within the manual weeding approach, no significant differences between the amounts of weed biomass were found.

Weeding only 2 times led to clearly higher weed biomass production than weeding 3 or 4 times. The differences within the frequency groups do not follow the same pattern. Within the 2 weeding groups the lowest weed biomass was produced when weeding was conducted at 12 WAP and at either 4 or 8 WAP. Skipping the 12 WAP weeding combined with either the 4 or 24 WAP weeding resulted in highest weed biomass production. When three weedings were conducted, the lowest weed biomass was produced when the 12 or 24 WAP weeding was skipped. Thus the early weedings were the most important ones in keeping weed biomass low.

There were no significant sites x weeding frequency interactions within the manual hand hoe approach. However, the weed biomass production was highly different between sites thus the magnitude of difference between a grass weed dominated site (Ido) and a broadleaf weed dominant site (Moniya) are shown. Generally weed biomass was lower at Moniya in all treatments and did not show consistent response to weeding frequency or timing. At Ido weed biomass was larger when 2 times weeded.

The treatments using post-emergence herbicide had a significant site x treatment interaction. Post-emergence herbicide application combined with weeding had consistent, yet not significant effects on weed biomass at Moniya. After a single application, weed biomass decreased further with every additional manual weeding. When a herbicide was applied twice, the weed biomass responded in the same manner, except for the treatment where both herbicide applications were followed by weeding. However the differences at Moniya were not significant. At Ido, single herbicide application did not keep weed biomass controlled through the first 24 WAP. The very high weed biomass was significantly larger at Ido than in the same treatment at Moniya. At least one manual weeding was required to reduce weed biomass. Double herbicide application reduced weed biomass to levels similar to those attained with one application and at least one follow up weeding except for the treatment in which both herbicide applications were followed by weeding. The extremely high weed biomass was caused by a plot in which Tithonia ‘escaped’ the herbicide and produced over 20 Mg/ha DM in the time between 12 and 24 WAP. The use of pre-emergence herbicide controlled weed biomass irrespective of follow up manual weeding. At Ido the pre-emergence application was not sufficient when the first 3 weedings (4, 8, 12 WAP) were skipped. However, the first 2 weedings could be skipped, keeping the weed biomass at levels comparable with those at Moniya.

The weed biomass in the un-weeded control at Ido was significantly larger than at Moniya. Weed biomass accumulation in the ‘weed free’ plots was the same in both sites. Farmer practice produced the same amount of weed biomass as weed-free at Moniya. However, at Ido the weed biomass in farmer practice was considerably higher than in weed-free plots. Preliminary results indicated that the weeding frequency trials show strong variation in weed biomass production under reduced weeding frequency and with modified timing. The technical approach, manual hand hoe, pre- or post-emergence herbicide appears to be of secondary importance as all approaches were able to reduce weed biomass to similar levels around the weed-free control. Research may need to concentrate more on best suited combinations of the approaches. However, conclusive results require the final root yields.

Objective 2: Identify effective and safe herbicides for weed control in cassava in Nigeria.

Key Milestone: Preliminary screening of candidate herbicides at IITA (Ibadan) to determine the best candidate herbicides for extensive testing in cassava cropping situation (sole cassava, companion crops and weeds) is carried out in year 1).

Output 4: Preliminary screening of candidate herbicides at IITA (Ibadan) to determine best herbicides for extensive testing in cassava cropping situations (sole cassava, companion crops and weeds).

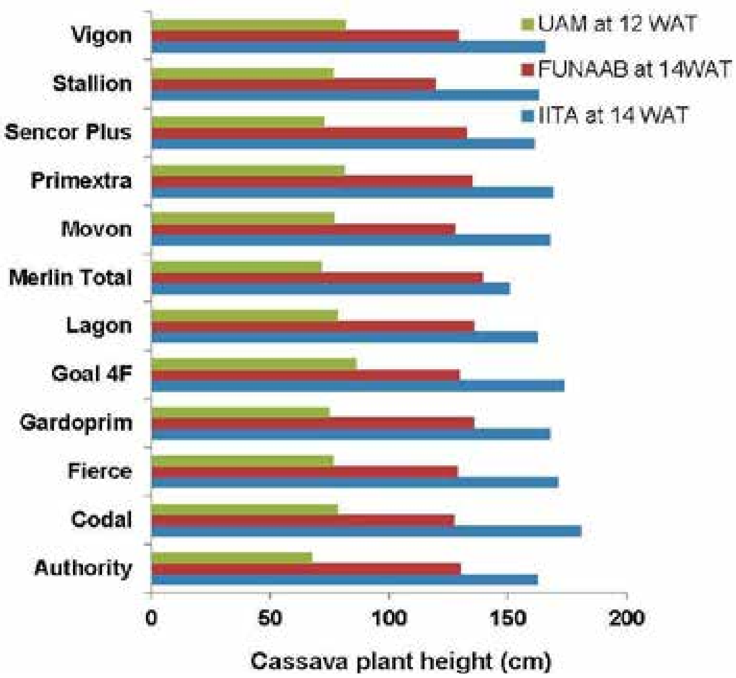
Preliminary screening of candidate herbicides was implemented by IITA in 2014 in the research farms of IITA, FUNAAB, UAM and NRCRI under controlled conditions. The result of the evaluation was presented in 2014 annual progress report without cassava root yield data. Cassava roots were harvested at 9 months after planting and the result is presented in this report.

A total of 22 pre- and 16 post-emergence herbicides at different rates with two non-herbicide treatments [hoe-weeded (3 times) and unweeded checks] were evaluated in two cropping seasons [1st season starting June 2014 and 2nd season starting August 2014]. Primextra Gold 720 SC which is already in use in Nigeria was included as a check. The first season evaluation was carried out in four locations and the second season in three locations. At each site, 49 pre-emergence herbicide treatments replicated 3 times (147 plots) and 33 post-emergence herbicide treatments also replicated 3 times (99 plots) were evaluated. An erect cassava variety, TME 419 at 10,000 plants/ha (1st season) and 20,000 plants/ha (2nd season) was used in the evaluation. In the second season, cassava was intercropped with cowpea, soybean, melon and maize at a seeding rate of 40,000 plants/ha. At all the sites, post-emergence herbicides were applied over cassava shoot at 3 WAP when cassava was at 3 to 5 leaf growth stage without adjuvant. At all sites and in both cropping seasons with the exception of the 2nd season evaluation in IITA, all plots treated with pre-emergence herbicides were hoe-weeded at 8 WAT. This operation was carried at 15 WAT for the 2nd season evaluation at the IITA research farm. Plots treated with post-emergence herbicides were manually weeded with hoe at 6 WAT.

Herbicides experiment in IITA Ibadan

Cassava harvest from pre-emergence herbicide treatments [1st season]

Cassava population was higher at NRCRI and UAM sites than at FUNAAB. The low cassava population at FUNAAB was not due to herbicide injury but as a result of poor sprouting of planting stakes. At this location, over 45% of cassava stakes did not sprout in the untreated plot. In general, cassava root yield was higher at NRCRI compared with UAM and FUNAAB. At all sites, cassava root yield differed significantly with type of herbicide and rate used. At NRCRI, Gardoprim Plus Gold at 10 L/ha had the highest root yield (27.1 t/ha). Plots treated with Gardoprim Plus Gold at 10 L/ha produced 6 t/ha and 12.3 t/ha more roots than Primextra Gold at 4.5 L/ha and the untreated hoe-weeded treatment. Root yields from plots treated with Liberator forte at 0.5 L/ha (24.6 t/ha), Bullet at 3.5 L/ha (23.8 t/ha), Vigon at both rates (23.1 & 23.5 t/ha), Goal 4F at 0.50 L/ha (22.9 t/ha), Movon at 1.5 L/ha (22.7 t/ha) and Merlin Total at 0.55 L/ha (22.5 t/ha) were comparable. At UAM, the highest root yield was obtained from plots treated with Merlin Flexx at 0.5 L/ha (17.6 t/ha) followed by yields from Merlin Total at 0.55 L/ha (16.8 t/ha), Codal Gold at 4.5 L/ha (16.2 t/ha) and Liberator forte at 0.5L/ha (15.2). Root yields from these treatments were 6.3 - 8.7 t/ha and 8.2 - 11.6 t/ha greater than yields obtained from plots that received Primextra Gold at 4.5 L/ha and the hoe-weeded treatment, respectively. At FUNAAB, the highest root yield was obtained from plots treated with Liberator forte at 1.5 L/ha (26.1 t/ha) followed by yields from Wing–P at 6 L/ha (24.8 t/ha), Sencor Plus at 1.5 L/ha (22.5 t/ha), Merlin Total at 0.33 L/ha (21.9 t/ha) and Bullet at 3.5 L/ha (21.1 t/ha). These herbicides produced 13.1-18.1 t/ha more roots than the hoe-weeded check. Similarly, plots treated with these herbicides produced 10.1 - 15 t/ha more roots than plots treated with Primextra Gold at both rates. Although cassava root yield differed with sites; Sencor Plus at 1.5 L/ha, Merlin Total at the two rates, Liberator forte at 1.5 L/ha, Wing-P at 6 L/ha, Vigon at 1.5 L/ha, Movon at 1.5 L/ha, Lagon at 1 L/ha, Gardoprim Plus Gold at 5 L/ha had higher root yields than root yields obtained from hoe-weeded plots in more than one site.



Effect of pre-emergence herbicides on cassava plant height at 12 WAT at UAM, and 14 WAT at FUNAAB and IITA in 2015.

Cassava harvest from pre-emergence herbicide treatments [2nd season]

Cassava population at harvest was 100% of target population in majority of the treatments except in plots treated with Gardoprim Plus Gold at 10 L/ha, Sencor at 0.6 L/ha, Stallion at 3 L/ha, Vigon at 1 L/ha and Wing-P at 4 L/ha at the IITA-Ibadan site. At the IITA-Ibadan site, plots treated with Merlin 75WG at 0.8 kg/ha (32.2 t/ha) produced the highest root yield. This was followed by yields from plots treated with Gradoprim Plus Gold at 5 L/ha (29.4 t/ha), Merlin Total at 0.55 L/ha (29.1 t/ha), Stallion at 3 L/ha (28.5 t/ha), Liberator forte at 0.5 L/ha (28.5 t/ha), Fierce at 0.32 kg (27.3 t/ha), Challenge at 2.5 L/ha (27.2 t/ha) and Gardoprim Plus Gold at 10 L/ha (26.7 t/ha). Cassava root yields from these treatments were twice higher than yields from plot treated with Primextra Gold at 4.5 L/ha and 10.4 - 15.9 t/ha higher than yields from Primextra Gold at 3 L/ha. The untreated hoe-weeded plot had root yield comparable to yields from plots treated with most herbicides but superior to Primextra Gold at both rates. At NRCRI, the highest root weight was obtained from plots treated with Merlin Total at 0.55 L/ha (26.8 t/ha). The untreated hoe-weeded plot had significantly higher yield than plots where Primextra Gold was used at 3 L/ha. Cassava root yield obtained from plots treated with Merlin Total at both rates, Authority at both rates, Fierce at 0.32 kg/ha, Lagon at 1 L/ha, Sencor Plus at 1 and 1.5 L/ha, Gardoprim Plus Gold at 5 L/ha, Codal Gold at 3 L/ha, Liberator forte at 0.5 L/ha and Movon at 1 L/ha were substantial at both sites.

Cassava harvest from post-emergence trials

Cassava population was lowest in the FUNAAB site. At each site, cassava plant population differed significantly among treatments. At the IITA site, cassava plants treated with Beacon at 53.2 g/ha, Cobra at 0.91 L/ha, Envoke at 7 g/ha, Fusion at 0.58 L/ha, Glean XP at 22 g/ha and Select Max at 1.17 and 1.75 L/ha maintained the target population of 10,000 plants/ha. At FUNAAB and IITA, Nicosulfuron at 1.5 L/ha reduced cassava population significantly. At UAM, plants treated with Beacon at 53.2 g/ha, Flexstar at 0.88 L/ha, Monitor at 15 g/ha and the untreated hoe-

Cassava from one of the weed controlled sites shows great potential weeded plot maintained the target plant population (10,000 plants/ha). Maister Power at 1.5 L/ha at NRCRI and UAM and Corum at 1.90 L/ha reduced cassava population the most. There was significant treatment effect on cassava root yield at all sites. In general, cassava fresh root weight/ha was higher at FUNAAB than the other sites even with the relatively low cassava population. For all herbicides, the lowest fresh root weights were obtained from the IITA site due to extreme poor soil fertility. Cassava fresh root weight at this site ranged from 6 - 9.4 t/ha. Cassava fresh root weight from untreated hoe-weeded treatment was 7.5 t/ha indicating that the poor root yields observed at this site was not due to effect of herbicides on the cassava. At FUNAAB, plants that received Envoke at 7 g/ha (25.5 t/ha), Fusilade at 3 L/ha (24.6 t/ha), Cobra at 0.91 L/ha (24.1 t/ha), Flexstar at 0.88 L/ha (20.4 t/ha) and Maister 61WG at 0.15 kg/ha (20.5t/ha) produce fresh root weight comparable to those in the untreated hoe-weeded plot (26.9 t/ha). At this site, Nicosulfuron at both rates depressed cassava fresh root weight/ha the most. At the NRCRI site, plants treated with Select Max at 1.75 L/ha and Fusion at 0.58 L/ha produced 6.8 - 7.2 t/ha more fresh root weight/ha than plants in the untreated hoe-weeded plot. Similarly, plants treated with Envoke at 10.5 g/ha and Gallant Super at 1 L/ha had 2.7-3.4 t/ha more fresh root weight/ha than plants in the untreated hoe-weeded plot. At UAM, plants in the untreated hoe-weeded treatment had the highest fresh root weight/ha (17.3 t/ha). Cassava fresh root weight from plants treated with Beacon at 53.2 g/ha, Maister 61 WG at 0.15 kg/ha, Envoke at 7 g/ha, Fusion at 0.58 L/ha, Fusilade at 4.5 L/ha, Glean XP at 22 g/ha, Gallant Super at 1.5 L/ha were comparable to root yield from plants in the untreated hoe-weeded plot.

Herbicide selection for extensive testing

At the second Annual Work Review and Planning meeting of the project held in April 29-30, 2015 at IITA, the sub-committee on herbicide use and safety selected twelve pre- [Authority, Codal Gold, Fierce, Gardoprim Plus Gold, Goal 4F, Lagon, Merlin Total, Movon, Primextra Gold, Sencor Plus, Stallion, Vigon] and five post- [Cobra, Select Max, Envoke, MaisTer Power, Maister 61 WG] emergence herbicides for extensive testing in 2015. The sub-committee selected these herbicides by (1) Creating a ranking system based on statistical analysis of cassava root yield, (2) Eliminating any products with weed control efficacy < 80%, (3) Eliminating products with cassava stand < 90%

Training on "Application and Safe Use of Herbicides" recieved support from Bayer CropScience and if there were products with two doses with the same rank, the product with the highest dose was eliminated. In addition to the above criteria, documents on EPA, Codex and EU classification of herbicides were consulted to ensure the health and safety of applicators of herbicides that will be finally recommended from the project.

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 agro-ecological zones is carried out in year 2.

Field experiments

Four field experiments were carried out in first and second cropping seasons in 2015 at different sites. 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 (in 6 sites) and 2 (in 4 sites) were set up as split plot in 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 & No pre-emergence herbicide with hoe-weeding] 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 within the season at all sites, the post-emergence herbicides in the subplot treatment were modified. Cobra, a broadleaf herbicide was replaced with sequential application of Select Max (a grass herbicide) and Cobra starting with Select Max to control broadleaves and grasses. Similarly, Select Max was replaced with Envoke to take care of broadleaves, grasses and sedges. Experiment 3 was setup as RCBD replicated three times in 6 sites. Two rates of each herbicide used in experiment 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 both seasons 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 allowed two weeks before ploughing. All fields were harrowed twice before ridging and planting crops. All post-emergence herbicide application was targeted to weeds under cassava canopy with a shield.

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

Cassava population and vigor: Cassava population varied significantly among pre-emergence herbicide treatments at 4 WAT. At all sites, except UAM cassava population was 81 - 99% of the target population. At UAM, the relatively low cassava population was due to termite damage to cassava stakes. Stakes damaged by termites were replanted At 6 WAT, cassava population at FUNAAB, NCRI (National Cereals Research Institute, Amakama, Abia State), ASUT (Akwa Ibom

State University of Technology, Abak) and UAM sites was > 90 % of target population. A similar trend was observed at IITA except in plots where Codal Gold was applied. Cassava population was lower at Onne compared with the other sites due to loss of viability. Cassava leaves in plots treated with Movon and Vigon were bleached but recovered at 3 to 4 WAT. Authority caused curling of apex cassava leaf but cassava recovered from this injury at 4 - 5 WAT. At all sites and for all herbicides, cassava growth was vigorous although plants in plots treated with Merlin Total and Sencor Plus were stunted at 2 to 3 WAT. Cassava plants in plots treated with these herbicides recovered later as depicted by cassava plant height at 14 WAT. At each site, cassava height varied among pre-emergence herbicide treatments. For all pre-emergence herbicides, cassava height was taller at the IITA site than at the FUNAAB at 14 WAT. With regards to the pre-emergence herbicides, plots treated with Merlin Total at IITA, Stallion at FUNAAB and Authority at UAM had shorter plants. With regards to the post-emergence herbicides, plots treated with Envoke had shorter plants at all sites. At each site, the interaction between pre- and post-emergence herbicide treatments affected cassava height significantly. At the IITA site, the tallest plants were observed in plots treated with Fierce + Zero Post, Goal 4F + Maister 61 WG, Codal + Hoe-weeded and Merlin Total + Hoe-weeded. At FUNAAB, the tallest plants were in plots treated with Vigon + Maister Power at 1.5 L/ha, Sencor Plus + Hoe-weeding, Primextra Gold + Hoe-weeding, Movon + Hoe-weeding and Authority plus + Hoe-weeding. In plots were Envoke was used, cassava plants tended to be shorter compared with cassava plants in the other treatments especially at FUNAAB and UAM sites. At these sites, the tips of cassava shoot in plots that received the herbicide were yellowish but cassava recovered within the season.

Weed control efficacy: At IITA, all pre-emergence herbicides provided > 90% control of broadleaf and grass weeds up to 8 WAT except Stallion (68%) and Primextra Gold (89%) without post-emergence herbicides. Stallion had better control of grasses (95%) than broadleaves at 8WAT. Merlin Total, Sencor Plus, Gardoprim Plus Gold, Fierce, Authority and Movon maintained > 90% up to 12 WAT without post-emergence herbicides. Plots treated with Codal Gold, Goal 4F, Lagon, Primextra Gold, Vigon and Stallion received post-emergence herbicides at 67 or 82 days after pre-emergence herbicide treatment (DAT) or both to provide > 90% weed control at 12 WAT. The time of application of post-emergence herbicides varied among replicates indicating variability in weed soil seed bank which was reflected in the above ground weed flora. At this site, pre-emergence herbicides had good (80 – 90%) to excellent (90 -100%) control of *Ageratum conyzoides, Calopogonium mucunoides, Centrosema pubescens, Chromoleana odorata, Corchorus tricularia, Desmodium scorpirus, Phyllanthus amarus, Solanum sp, Spermacoce ocymoides* and *Spigelia anthelmia*. P*assiflora foetida* and *Ipomoea mauritiana* were the most difficult weeds at this site to control. Merlin Total, Sencor Plus, Fierce, Gardoprim Plus Gold, Lagon and Authority provided > 90% control of these weeds.

At FUNAAB, all pre-emergence herbicides with the exception of Codal Gold, Gardoprim Plus Gold, Goal 4F, Lagon, Movon, provided 80-84% control of broadleaf weeds up to 8 WAT without post-emergence herbicides. All pre-emergence herbicides provided 81-93% control of grasses up to 8 WAT. Plots treated with Codal Gold, Goal 4F, Lagon, Movon, Stallion, Vigon and Gardoprim Plus Gold received post-emergence herbicides as early as 33 or 47 DAT. In plots treated with Merlin Total, Sencor Plus, Fierce, and Authority post-emergence herbicides were applied either at 80 or 90 DAT or at both dates. Within the pre-emergence herbicide treatments, Maister Power, Maister 61 WG and Select Max + Cobra were more consistent in controlling broadleaf weeds and grasses. At this site, major weeds were *Panicum maximum, Passiflora foetida, Ipomoea mauritiana, Commelina benghalensis, C. diffusa, Talinum triangulare, Centrosema pubescens, Tridax procumbens, Calopogonium mucunoides*, *Senna occidentalis* and sedges especially *Cyperus spp*. Depending on stage of growth of these weeds, Merlin Total, Sencor Plus, Fierce, Lagon, Gardoprim Plus Gold and Authority with application of Maister Power, Envoke and Select Max + Cobra provided good control of these weeds. Envoke provided excellent control of grasses but was not effective in controlling *Panicum maximum.*

At NRCRI, all pre-emergence herbicides provided 92-98% control of broadleaves and grasses with the exception of Stallion (85%) and Lagon (89%) without post-emergence herbicides or hoe-weeding up to 6 WAT. Merlin Total, Sencor Plus, Fierce, Gardoprim Plus Gold, Movon, Vigon and Primextra Gold provided excellent (> 90%) control of broadleaf weeds without post-emergence herbicides up to 8 WAT. Authority, Codal Gold and Goal 4F provided good (82-88%) control of broadleaf weeds without post-emergence herbicides up to 8 WAT. Lagon (67%) and Stallion (65%) did not provide good control of broadleaf weeds up to 8 WAT without post-emergence herbicides. All pre-emergence herbicides provided 88 - 98% control of grasses up to 8 WAT without post-emergence herbicides. All pre-emergence treatment with the exception of plots treated with Merlin Total, Sencor Plus and Movon were treated with post-emergence herbicides at 62 DAT. Merlin Total, Sencor Plus and Movon did not require post herbicides up to 95 DAT.

At UAM, Merlin Total provided 90 - 91% control of broadleaf and grassy weeds up to 8 WAT without post-emergence herbicides. Plots treated with this herbicide received post-emergence at 63 and 85 DAT. Gardoprim Plus Gold and Vigon provided excellent (91%) control of broadleaf weeds up to 8 WAT with post-emergence herbicides applied at 48 DAT. The other pre-emergence herbicides [Authority, Fierce, Goal 4F, Lagon, Movon, Primextra Gold, Sencor Plus, and Stallion] provided 80- 85% control of broadleaf weeds up to 8 WAT with post-emergence herbicides at 32 or 48 DAT. Plots treated with Lagon required post-emergence herbicide at 48 DAT to provide up to 90% control of grasses at 8 WAT. All other herbicides provided 80-88% control of grasses up to 8 WAT with post-emergence herbicides applied at 32 or 48 DAT. At this site, some pre-emergence herbicides (Goal 4F, Stallion, Primextra Gold, Codal Gold and Fierce) required more than two repeat applications of post-emergence herbicides within the season to keep weeds in check. Overall, Maister Power, Envoke and Select Max + Cobra had better weed control efficacy than Maister 61 WG. Major weeds at this site were *Acalypha ciliata, Ageratum conyzoides, Boerhavia erecta, Brachiaria deflexa, Commelina bengalensis, Cyperus rotundus, Digitaria horizontalis, Euphobia heterophylla, Fimbrristylis sp, Rottboellia cochinchinensis, Tridax procumbens,* and *Vernonia ambiqua.* All pre-emergence herbicides combined with post-emergence herbicides provided good control of *A. ciliata, A. conyzoides and D. horizontalis, Fimbristylis sp, Hyptis suaveolens, Mitracarpus villosus,* and *Pennisetum polystachion, T. procumbens, V. ambiqua* at 8 WAT. Merlin Total combined with either Maister Power or Envoke controlled *C. benghalensis.* Envoke when combined with most pre-emergence herbicides provided very good to excellent control of *C. rotundus,* other sedges and *R. cochinchinnensis.* Envoke was very effective on grasses and sedges especially on *Rottobeollia cochinchinensis* even when applied to the weed at an advanced growth stage of the weed.

At ASUT, Vigon, Sencor plus and Merlin Total provided ≥ 90% control of broadleaf weeds up to 8 WAT without post-emergence herbicides. Similarly, plots treated with Gardoprim Plus Gold, Goal 4F, Movon and Primextra Gold had 80-82% control of broadleaf weeds up to 8 WAT without post-emergence herbicides. Plots treated with Vigon, Sencor Plus, Merlin Total, Gardoprim Plus Gold, Goal 4F, Movon and Primextra Gold received post-emergence herbicides at 60 or 90 DAT. Authority, Stallion and Codal Gold provided 80 - 84% control of broadleaf weeds up to 8 WAT only with post-emergence herbicides application at 46 DAT. Plots treated with Authority, Stallion and Codal Gold received additional post-emergence herbicide application at 60 and 99 DAT. Fierce and Lagon provided < 80% control of broadleaf weeds at 8 WAT without post-emergence herbicides. At this site, all pre-emergence herbicides with the exception of Lagon (79%), provided 82-96% control of grasses up to 8 WAT with application of post-emergence herbicides as described for broadleaf weeds.

At Onne, all pre-emergence herbicides provided ≥ 80% control of broadleaf weeds and grasses except Stallion (52%) at 6 WAT. At this site, all pre-emergence herbicides with the exception of Merlin Total and Sencor plus received post-emergence herbicides at 55 DAT. Merlin Total and Sencor plus received post-emergence herbicides at 76 or 100 DAT.

Overall, result from the sole cassava experiment show that the most consistent weed control with pre-emergence herbicides across sites in a decreasing order of importance was obtained from Merlin Total > Sencor Plus > Gardoprim Plus Gold > Fierce > Primextra Gold > Movon = Lagon.

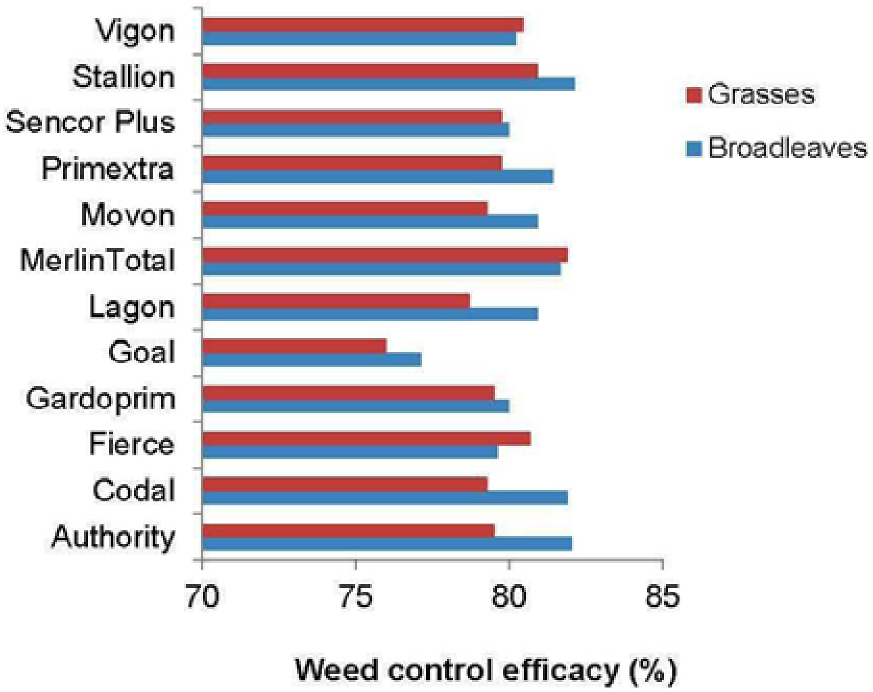
All pre-emergence herbicides were supplemented with post-emergence herbicides at 76 and 100 DAT to provide 80 – 96% weed control up to 10 WAT.

Overall, result from the sole cassava experiment show that the most consistent weed control with pre-emergence herbicides across sites in a decreasing order of importance was obtained from Merlin Total > Sencor Plus > Gardoprim Plus Gold > Fierce > Primextra Gold > Movon = Lagon. Although Lagon was marginally better than Movon in weed control, it was not as consistent as Movon across sites. For post-emergence herbicides, Maister Power > Maister 61 WG > Select Max + Cobra were the most consistent. These herbicides have great potential for weed management in cassava and are therefore suggested as good candidates for on-farm testing.

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

Cassava and maize population and vigor [First cropping season]: At all sites, with exception of UAM, 84 - 99% of target cassava population was achieved at 4 and 6 WAT. At UAM, cassava population in plots treated with Merlin Total, Stallion and Vigon was 62%, 78% and 70% of the target population, respectively at 4 WAT. At all sites, maize population varied significantly among pre-emergence herbicide treatments at 4 and 6 WAT. At IITA, the highest maize population was obtained from plots treated with Primextra Gold followed by Stallion at 4 WAT. Maize population in the two treatments was comparable at 6 WAT. At FUNAAB site, the highest maize population was obtained from plots treated with Movon and Fierce and at UAM, the highest maize population was from plots treated with Movon and Codal Gold at 4 WAT. A similar trend in maize population was observed at 6 WAT in IITA and FUNAAB sites. At all sites, the target maize population of 40,000 plants/ha was not achieved even in the untreated treatment. In the no pre-emergence herbicide + hoe-weeded plots; 74% of the target maize population at the IITA site, 70% at FUNAAB, and 68% at UAM sites was achieved. For the on-farm trials there may be the need to consider changing this maize variety. At all sites, maize growth was vigorous to highly vigorous but was infested with maize streak virus and stem borers at the IITA site. Movon and Vigon bleached maize leaves which recovered 2 to 3 DAT.

Weed control efficacy [First season]: For all pre-emergence herbicides, weed control was better at IITA and NCRI sites than at FUNAAB and UAM at 6 WAT. At IITA and NCRI sites, all herbicides consistently provided good (80-90%) to excellent (90-100%) control of broadleaves and grasses without post-emergence herbicides up to 6 WAT. At IITA, all pre-emergence herbicides with the exception of Primextra Gold (88% for broadleaves) maintained excellent broadleaves and grasses up to 8 WAT without post-emergence herbicides. At this site, post-emergence herbicides were applied at 67 DAT. At NCRI, Merlin Total maintained excellent (> 90%) control of broadleaves and grasses up to 8 WAT without post-emergence herbicides. For this herbicide, post-emergence herbicides were applied at 95 DAT. Lagon provided 90% control of grassy weeds without post-emergence up to 8 WAT. Other pre-emergence herbicides at this site had post-emergence herbicide at 62 DAT. At FUNAAB, Authority, Fierce, Gardoprim Plus Gold and Merlin Total, provided (82-89%) control of broadleaf weeds without post-emergence herbicides. At this site, all pre-emergence herbicides had good control of grasses. Merlin Total, Sencor Plus, Gardoprim Plus Gold maintained good weed control up to 8 WAT without post-emergence. Plots treated with these herbicides received post-emergence at 80 or 90 DAT. At UAM, weed control at 6 WAT was below 70% except in plots treated with Merlin Total, Fierce, Vigon and Stallion which provided 70-80% control of broadleaves and grasses. At this site, post-emergence herbicides were applied as early as 32 DAT with the exception of plots treatment with Primextra Gold, Authority, Fierce, Sencor Plus and Merlin Total. For these herbicides, post-emergence herbicides were applied at 63 DAT. Post-emergence herbicides differed significantly in broadleaf and grass weed control at 8 WAT at FUNAAB and UAM sites. Control of broadleaf weeds by post-emergence herbicides in FUNAAB was not as good as control observed at IITA, UAM and NCRI due to the presence of *I. mauritiana* and *P. foetida*. At FUNAAB, the interaction between pre- and post-emergence herbicides on control of broadleaves and grass was significant. In general, application of post-emergence herbicide enhanced weed control. At FUNAAB, Maister Power, Maister 61 WG and Envoke were consistent in providing good to excellent control of broadleaves and grasses.

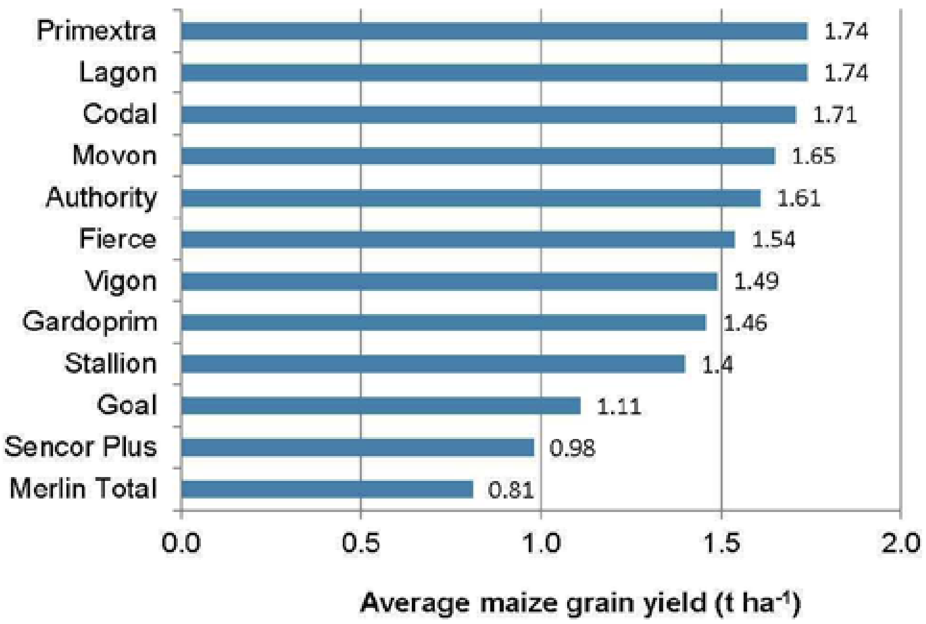


Efficacy (%) of pre-emergence herbicides on broadleaves and grasses in cassava/maize intercrop in the second cropping season in 2015.

Maize grain yield [First season]: At all sites, maize population at grain harvest differed significantly among pre-emergence herbicide treatment. For all pre-emergence herbicides, maize population was lower at IITA site due to stem borer attack. At this site, plots treated with Sencor Plus, Merlin Total and Authority had the lowest maize population. At all sites, maize grain yield differed significant among pre-emergence herbicide treatments. For all pre-emergence herbicides, maize yield was higher at UAM than at FUNAAB. At IITA, the highest grain yield was obtained from plots treated with Primextra Gold followed by yields from plots that received Stallion, Vigon, Gardoprim Plus Gold and Lagon. At FUNAAB, Primextra Gold again produced the highest grain yield follow by grain yields from Fierce, Lagon, Stallion,and Gardoprim Plus Gold . At UAM, Codal Gold produced the highest grain yield. This was followed by Lagon, Movon and Authority. The lowest grain yields were obtained from plots treated with Sencor Plus and Merlin Total at IITA and FUNAAB sites. Although substantial grain yields were obtained from plots treated with Sencor Plus and Merlin Total at the UAM site, they should not be used for weed control in maize intercrop. These two herbicides affected maize growth negatively and depressed maize grain yield at the other sites. Average maize grain yield across sites show in an increasing order of importance that Lagon = Primextra Gold > Codal > Movon > Authority > Fierce > Vigon > Gardoprim Plus Gold may be appropriate for weed control in maize/cassava intercrop. Post-emergence herbicides affected maize grain yield significantly at UAM and FUNAAB. At UAM, application of Envoke lead to pre-mature senescence of maize plants already with cobs. The injury symptom was obvious at UAM and FUNNAB. For all pre-emergence herbicides, plots treated with this herbicide had the lowest maize grain yield. At all sites, the interaction between pre- and post-emergence herbicides was not significant.

Average maize grain yield across sites show in an increasing order of importance that Lagon = Primextra Gold > Codal > Movon > Authority > Fierce > Vigon > Gardoprim Plus Gold may be appropriate for weed control in maize/cassava intercrop.

Weed control efficacy [Second season]: At this site, all pre-emergence herbicides with the exception of Goal 4F provided 80-81% control of broadleaves and grasses up to 8 WAT. All the herbicides except Merlin Total and Sencor Plus required post-emergence herbicides at 39 DAT to maintain good weed control. Merlin Total and Sencor plus provided very good control of broadleaves and



Average maize grain yield from plots treated with pre-and post-emergence herbicides in cassava intercropped with maize in the three sites in the first cropping of 2015.

grasses for more than 8 WAT without post-emergence herbicides. Plots treated with Merlin Total and Sencor Plus required post-emergence herbicides at 81 or 91 DAT.

Maize population and grain yield [Second season]: Maize population was affected significantly by pre- and post-emergence herbicides. Merlin Total depressed maize population significantly. Plots treated with Lagon had the highest maize population (32,917 plants/ha). Plots treated with Gardoprim Plus Gold and Goal 4F had > 31,000 plants/ha. Maize grain yield differed significantly with herbicides treatments. Plots that received Lagon produced the highest grain yield (2.28 t/ha). This yield was comparable to grain yields obtain from Gardoprim Plus Gold (2.18 t/ha), Fierce (2.0 t/ha) and Primextra Gold (2.0 t/ha). Plots treated with Merlin Total (0.81 t/ha) had the lowest yield. This result show in a decreasing order of importance that Lagon > Gardoprim Plus Gold > Fierce > Primextra Gold > Goal 4F > Authority > Vigon > Stallion > Movon are suitable for maize production in cassava/maize intercrop. The interaction between pre- and post-emergence herbicide was significant. In general, supplementing pre-emergence herbicide with a post-emergence herbicide produced higher maize grain yield except when pre-emergence herbicide were supplemented with either Select Max + Cobra or Envoke. Plots treated with Gardopim Plus Gold and Authority and supplemented with Select Max + Cobra did not follow this trend. With the exception of Merlin Total, supplementing pre-emergence herbicides with Maister 61 WG, Maister Power at 1 L/ha or at 1.5 L/ha (or both) produced the highest maize grain yield (Annex 2.1). This result show that Maister 61 WG and Maister Power could be used as directed spray to control weeds in cassava/maize intercrop.

Considering the weed control efficacy of the pre-emergence herbicides and maize grain yield from plots treated with these herbicides, the following pre-emergence herbicides in decreasing order of importance are suggested for on-farm testing for weed control in cassava-maize intercrop: Lagon > Gardoprim Plus Gold > Primextra Gold > Fierce > Authority > Movon. For post-emergence herbicides, Maister Power and Maister 61 WG were the most consistent and therefore suggested for on farm testing.

Considering the weed control efficacy of the pre-emergence herbicides and maize grain yield from plots treated with these herbicides, the following pre-emergence herbicides in decreasing order of importance are suggested for on-farm testing for weed control in cassava-maize intercrop: Lagon > Gardoprim Plus Gold > Primextra Gold > Fierce > Authority > Movon. For post-emergence herbicides, Maister Power and Maister 61 WG were the most consistent and therefore suggested for on farm testing.

Godwin Atser (IITA), Friday Ekeleme (IITA), and Steve Weller (Purdue) inspecting a herbicides treated field.

Result of experiment 3 [Rate study for pre-emergence herbicides]

This study was carried out to determine appropriate rates of pre-emergence herbicides for sole cassava. At all sites, and for all herbicides, with the exception of Merlin Total, cassava population in the lower rate herbicides was similar to the population in the higher rate at 6 WAT. Similarly for each herbicide cassava vigor was not significantly affected by herbicide rate at 6 WAT. In general, the lower rate resulted in similar total weed control as the higher rate at 6 WAT, except for Stallion at FUNAAB, NCRI, UAM and ASUT, Lagon at UAM and ONNE, Sencor Plus at UAM, Primextra Gold at UAM, and Goal 4F at UAM. A similar trend was observed in broadleaf and grass weed control at 8 WAT at IITA, FUNAAB, NCRI and ASUT.

Output 6. One or more ALS-targeted herbicides that can be used as post-emergence in cassava-production systems to control all major weeds, regardless of cassava's current sensitivity to the herbicide(s) is identified.

This output was achieved. Sixteen post-emergence herbicides were evaluated in 2014 with a repeat in 2015. Gyphosate and Imazapyr were the promising herbicides in terms of total vegetation control. Glyphosate and Imazapyr killed both cassava and weeds when applied over-the-top of cassava and weeds. Both herbicides are registered for use in Nigeria. These two herbicides are suggested for consideration in developing herbicide resistant cassava.

Output 7: Quality analysis of cassava roots and leaves treated with herbicides is carried out by IITA in year 3.

On its first meeting in 2014, the Project Steering Committee [SC] directed that quality analysis of cassava roots and leaves should be carried out in year 1 (2015) as against year 3 (2016) specified in the Project document. Based on this directive, the former Program Officer at the Bill & Melinda Gates Foundation, Mr. Vasey Mwaja, recommended South African Bureau of Standards [SABs] for the analysis. After several consultations and engagements with SABs, 38 samples of cassava roots and leaves were sent to the Laboratory in South Africa on 3 June 2014 with a comprehensive list of herbicides and active ingredients used in treating the cassava. SABs was also requested to conduct the residue analysis on cassava peel. On 22 July 2015 the Project received the result of the analysis from SABs. The result was circulated to members of the Sub-committee on herbicide use and safety who noticed that wrong standards were used for the residue analysis. SABs was approached for clarification on the standards used for the analysis. In an email of 5 October 2015 SABs finally indicated that they will not be able to conduct the analysis as requested.

Following this development, Prof. Steve Weller of Purdue University was approached to identify a laboratory in the United States for this analysis. The Pacific Agricultural Laboratory, LLC, 12505 NW Cornell Road, Portland, OR 97229-5651 was identified to repeat the analysis. The laboratory has presented Certificate of Accreditation to IITA with a list of analytical standards in their laboratory. Bayer CropScience has signed an agreement with the laboratory and provided the Lab. with six analytical standards of active ingredient in their products which the Lab. does not have. Cassava root and leaf samples will be sent to the Lab. in March for residue analysis. The analysis will also include cassava peel. Samples of maize grain from plots treated with promising herbicides for maize production will also be sent to the Lab. for residue analysis.

Objective 4. Involve farmers and other stakeholders in the research to develop improved weed management practices in cassava and; 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: (A) To convey an initial meeting with the ADPs. (B) To analyze extension capacities and training needs assessments of the three state-based ADPs.

Output 1: Extension capacities and training needs assessments are analyzed.

Following the first convening of the Agricultural Development Programs (ADPs) in 2014 at the Kick-off meeting of the Project in 2014, the Project team continued to engage the ADPs. In 2015, the Project team visited the ADPs — Abia, Benue, Ogun and Oyo state. The meetings also paved the way for sensitization on implementation of a Training Needs Assessment (TNA) study. The TNA was conducted and results were shared with partners. The TNA provides the Project team with the knowledge gaps in the extension systems. An abstract was developed on the state of extension systems. This was presented at the World Congress on Roots and Tuber Crops in China. The team is working towards developing a paper from the TNA study for journal publication.

In addition, a Communications Officer, Social Media Expert, and a Photographer were hired. The Project team also identified communication focal persons in partner organizations. During the year, the institutional capacities of the extension partners were analyzed and best communication mechanisms and channels identified.

Key Milestone: (A) To negotiate and conclude roles and responsibilities in the extension activities for this project. (B) To sign 3 MoUs with state-based ADPs and partner organizations.

Output 2: Three tripartite Memoranda of Understanding between the three state-based ADPs, partner organizations, and IITA are signed.

Extension agents being mobilized for Training Needs Assessment

During the period, the Project team negotiated roles and responsibilities in the extension activities for the Cassava Weed Management Project. Subsequently four Memorandum of Understandings (MoUs) were signed with the four state-based ADPs.

Output 1: Preliminary set-ups for effective extension and communication material development and dissemination are completed by the end of year 2.

Activities for preliminary extension were completed in year 2. Specifically, the Project team identified three communication focal persons from the partner organizations to ensure smooth collaboration and exchange of research and extension approaches and results. The Training Needs Assessment which was conducted helped the Project team in diagnosing the institutional communication capacities of existing extension partners. Communication mechanisms and channels were assessed. Regular meetings with communication focal persons, twice a year, were conducted on rotational basis.

Key Milestone: (A) Communications Officer to implement, via a consultant, a situational analysis and communications needs in each of the local governments (FGD, KAPs) (B) During the implementation of the KAP study, a community assessment is conducted to identify existing extension partners at community level. (C) Results of the KAP study and community assessment will be shared amongst partners and key stakeholders.

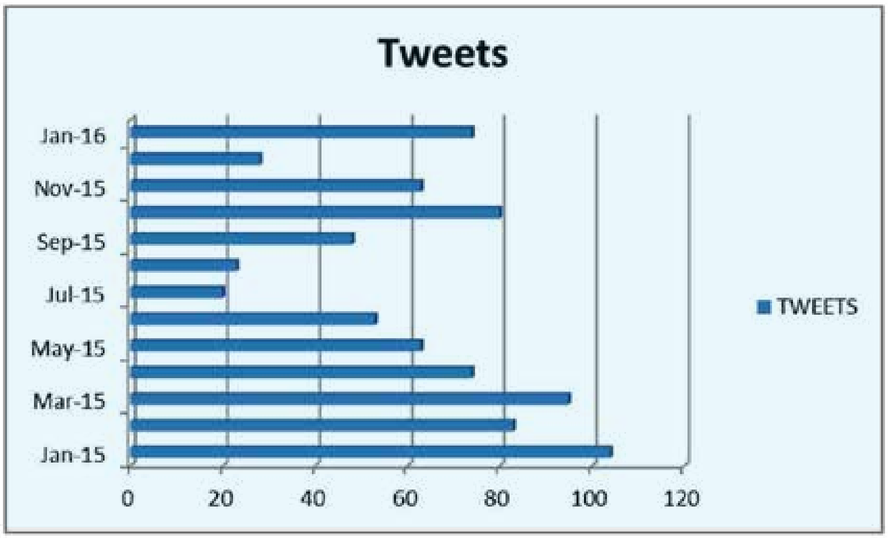
Output 2: A community assessment and 22 focus group discussions are conducted in 11 local governments (1 for women and 1 for men) by year 2.

The Project team conducted knowledge, attitudes, and practices (KAP) study involving 33 Focus Group Discussions (FGDs)with a total of 196 participants (women, youth and men disaggregated) to generate work indicators on what the gaps in information, attitudes, and improved practices of cassava weed management are, and to be able to develop appropriate materials to answer these

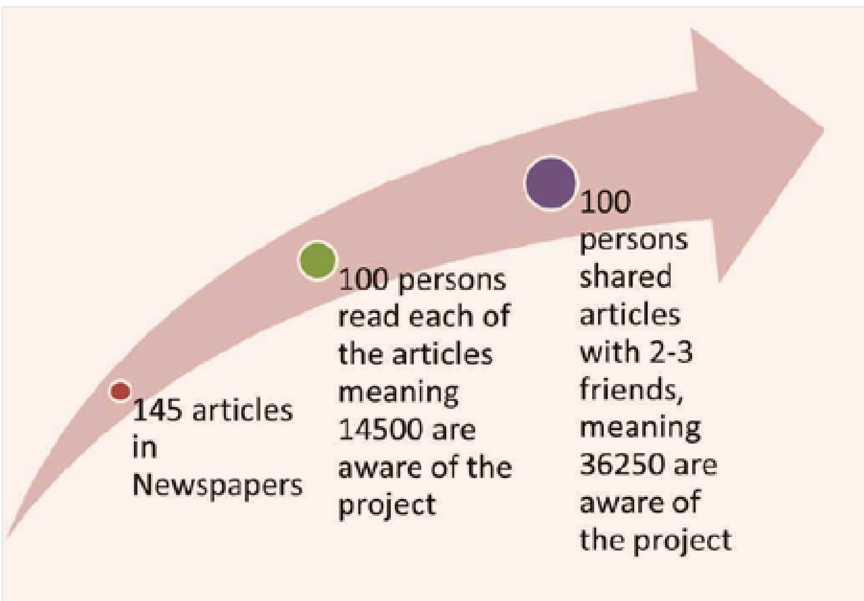
Cassava Weed Management Team conducting a KAP study in Benue State communication needs. Results of the KAP study were shared with partners in a report. Based on the findings from the KAP study and TNA, a curriculum for training of trainers has been developed.

Key Milestone: (A) Communications Officer to generate content on research interventions. (B) Communications team to research findings into user-adapted formats. Social media expert to upload all content on the website and create online dialogue.

The Social media traction for the Cassava Weed Management Project in the year 2015 increased significantly. The website (http://www.cassavaweed.org/) had 634 downloads and 2 videos were uploaded. The Twitter account (https://twitter.com/Cassavaweedmgt) has 337 followers, and the Facebook account (https://www.facebook.com/cassava.weedmgt) has 473 contacts on the profile and 369 likes for the page (https://www.facebook.com/Sustainablecassavasystems). The LinkedIn account (https://www.linkedin.com/in/cassava-weed-management-project) has 922 followers. The Project also has accounts on Slideshare (http://www.slideshare.net/CassavaWeed14), with 18 uploaded documents, and 2,210 views on Flickr; Pinterest and Google+. The Youtube channel has 10 uploaded videos with a total of 256 views.



Twitter impression trend



Trajectory of awareness of Cassava Weed Management Project in the newspapers

Key Milestone: (A) Communications Officer, and focal persons, to generate research content, convert to a language for non-scientists and adapt the format for press-release services. (B) The photographer to collect people-centered photo materials for the newsletters. (C) The Communications Officer will identify a release service for targeting the best stakeholders in Nigeria. (D) The Communications Officer will send out the newsletters and press releases on a quarterly basis.

Output 1: Quarterly newsletters are uploaded on the website (from last quarter of year 1 onwards) and disseminated to governmental services, partners, potential donors, and media release services, providing summaries on the research process for non-scientists.

Four quarterly newsletters were produced during the year and were shared to an audience of more than 2,000 persons. Limited print copies were also made and distributed during exhibitions. The team developed 18 press releases and sent to journalists with an estimated persons-reach of 36,250 persons who have become aware of the Project.

L-R: Alfred Dixon (Project Leader) compares notes with Ylva Hillbur (Deputy Director General, IITA) during a field visit to the Project's trials in Ibadan

Objective 5: Ensure project impact through good governance and effective management strategies for result handover to national partners.

Key Milestone: One workshop organized

The Project successfully organized the 2015 Annual Review & Work planning meeting with a wide range of stakeholders on 29 – 30 April 2015 at IITA, Ibadan. The 66 participants who were in attendance were from the Gates foundation, Partner institutions (FUNAAB, NRCRI, UAM), Government Regulators (SON, NESREA, NAFDAC), chemical companies (Syngenta, Bayer CropScience, Monsanto, etc.), UNIPORT, FMARD, private farms, National Cassava Growers Association (NCGA), ADPs, and farmers. The objective of the meeting was to jointly assess the achievements of the Project in Year 1 (2014), and plan for the implementation of activities in Year 2 (2015). Achievements in the following areas were discussed - Project Management, Agronomy, Herbicide Screening, Mechanical Weeding, Communications/Knowledge Exchange. Project Coordinators from partner institutes, IITA Project Administration Office (PAO) and the Monitoring and Evaluation consultant of the project also gave updates. Thereafter, Year 2015 work plan was drafted, discussed in details and finalized..

Participants at the 2014 Annual Review and Work Planning Meeting in Ibadan

Key Milestone: Steering Committee meeting held.

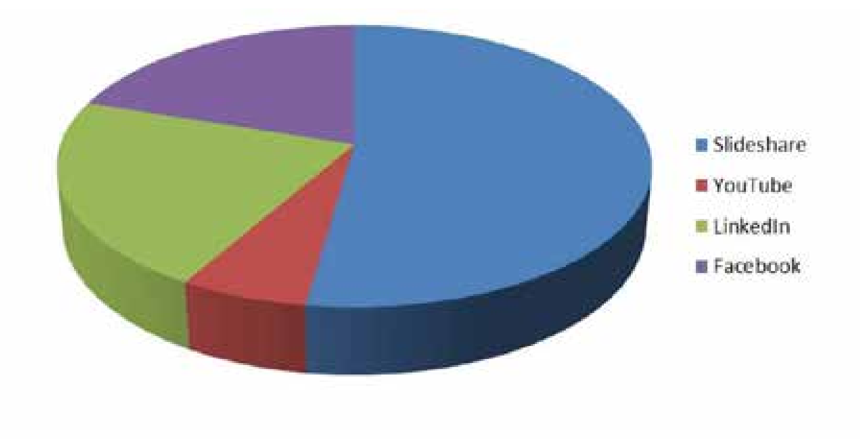
The second meeting of the Project's Steering Committee (SC) and its sub-committees were held at IITA campus, Ibadan on 4 – 5 May 2015. There was a 100% representation of all the members of the SC. Sub-committee members for Herbicides and Herbicides Safe Usage were also in attendance as resource persons at the meeting. The meeting was presided over by the SC chair, Dr. Julius C. Okonkwo (Executive Director of NRCRI). The 13 suggestions/recommendations at the end of the meeting were signed by the SC Chair and distributed to the members of the SC including the representative from the Bill & Melinda Gates Foundation. On the second day of the meeting, a field trip was organized for the SC to witness a demonstration of mechanical weeding in a cassava field, and to visit a Project implementation site at Ido as well as a small scale gari processing center along the way to the Ido site. The full report of the meeting was documented and distributed to members.


Members of the Steering Committee during a field visit in Ibadan

Key Milestone: Webportal operational.

Output 2: The project's website is up

The Project's website was operational all through 2015 (http://www.cassavaweed.org) as part of efforts to increase the visibility and good image of the Project and to promote knowledge sharing. 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 2015. Throughout the period, the project never had bad press.



Reach representation of some selected social media platforms

Participants during a training session on cassava weed management in IITA Ibadan

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.

A key activity of this Project is that in year 2, PAO will initiate 'learning-by-doing' models for trainees who will come to IITA for two weeks for hands-on involvement in the project's management, coupled with training visits of Project staff to NRCRI to work with the trainee in her/his own environment.

Sequel to the situational analysis conducted at NRCRI by the IITA team in October 2014, the 'learning - by – doing' training model was used to further build the capacity of NRCRI staff (especially the administrative and finance project staff) in project management, communication, administration, and accounting in order to provide the needed strong support for the desired success even beyond this phase of the project.

The approach used for the 'learning-by-doing' training was to organize practical hands- on involvement in project management activities in IITA for NRCRI Project staff - Ms. Ngozi Onyeji, and Mr. Silver C. Onwusiribe (NRCRI Cassava Weed Management Project's administrator, and accountant, respectively) for the period 11 – 22 May 2015 (two weeks). While in IITA for the training, the staff participated in the Project's activities together with IITA project staff. Their activities while at IITA also involved scheduled time with all IITA PAO staff to understand their various job functions in Project Administration Office. They also visited the Finance Directorate, Procurement and Supply Chain, and Cassava Weed Management Project staff . The IITA team comprising a representative of IITA Project Administration Office (PAO) and the IITA Cassava Weed Management Project's administrator and accountant followed up with a 3 – day training visit to NRCRI in September 2015. The objective was to ensure that NRCRI puts in place necessary machinery in readiness for the leadership role in Years 4 and 5 of the project. The IITA team had interactions with the institute's Executive Director, head of accounts, and head of administration to ascertain their readiness for seamless operation after the hand-over. There are plans that this approach towards capacity building in NRCRI will continue, and be expanded in 2016 with additional placement of NRCRI staff temporarily in IITA Ibadan to allow them to learn step-by-step the important issues involved during the critical phases in planning, implementing and conducting project activities.

In addition, the Project conducted training workshops for project staff of IITA, NRCRI, FUNAAB and UAM to upgrade their technical skills in agronomy and weed science, gender mainstreaming, and statistical analysis of data as well as understanding the social media as a resource. Details of training courses include:

1. Training course on "Correct Cassava Harvest in 5 Factorial Agronomy Trials" (11 – 13 March 2015) facilitated by Dr. Stefan Hauser: Thirty males and 26 females were trained. Owing to the complex nature and large cassava agronomy trials set up in the course of the project, this training became expedient to ensure that correct data are obtained across the locations.

2 Training workshop on "Application Techniques and Safe Use of Pesticides" (27-28 April 2015) facilitated by Dr. Mohamed Elsherif, Agronomic Product Development Manager & Technical Advisor from Bayer CropScience, Germany; and Prof. Friday Ekeleme. Participants included 47 males and 29 females drawn from partner institutions, Michael Okpara University of Agriculture Umudike, IITA, farmers and regulatory agencies (NESREA, SON and NAFDAC).

3. Training on "Operation of Mechanical Weeders for Field Experimentation" (25 – 27 May 2015: A total of 23 trainees selected from FUNAAB, IITA, UAM, and NRCRI were trained on the use, maintenance and operation of mechanical and manual weeders (brush cutter, small and big motorized Mantis weeders, and 3 manual weeding machines acquired from AfricaRice). The objective of the training was to make the participants become familiar with the operation of the weeding machines, how to carry out basic maintenance and repairs on the machines, as well as being able to train others.

4. On the ground training on "Correct Use of Ceptometer and Data Handling" (July – August 2015): Project staff (61 males and 15 females) drawn from IITA and the partner Institutions (NRCRI, UAM and FUNAAB) participated.

5. Gender Training Workshop for project staff of the Cassava Weed Management Project (21 – 22 October 2015) conducted at NRCRI by Prof. Janice Olawoye of University of Ibadan. Participants included 19 male and 19 females. The objective was to strengthen the skills of project staff at IITA and partner institutions on mainstreaming gender equality in their agricultural research and development activities. The training afforded participants an opportunity to gain practical skills on measuring organizational capacities to address and mainstream gender in their work and institutions.

6. Statistical Data Analysis Workshop for project staff was conducted across the three partner institutions [FUNAAB (05 – 08 October 2015), NRCRI (14 – 16 & 19 October 2015), and UAM (17 – 19 November 2015)]. Facilitated by the IITA biometrician, aspects covered during the training included review of statistics and theoretical background relevant to design and analysis

of agricultural experiments, review of basic experimental designs, field layouts and data entry format, and data analysis using SAS statistical software.

7. Training on “Understanding the Social Media as a Resource’’ was first organized in-house for project staff at IITA (27 February 2015), and later organized for project staff of partner institutions (20 October 2015) during the 4th Joint Review Meeting of the project held at NRCRI.

Meetings

1. Three Joint Project Review Meetings for project staff at IITA and partner institutions were held in 2015 as follows: IITA (25 February), FUNAAB (18 August) and NRCRI (20 October). The meetings took stock of the progress of project implementation with a view to addressing any implementation challenges.

The Federal University of Agriculture Abeokuta (FUNAAB) hosts one of the Joint Review Meetings (JRM)

2. The project hosted the 2nd and 3rd Nigerian Engineers’ brainstorming sessions on 18 – 22 May and 5 – 7 October 2015 to improve on the modification of mechanical weeders, prepare drawings showing specifications of the modifications on the small and big Mantis weeders, and produce a draft paper for a journal publication of the modification(s) done.

Transition Plans of Cassava Weed Management Project leadership from IITA to NRCRI

Three meetings (two internal meetings and 1 meeting with NRCRI management) were held on the transition plans of the Project’s leadership from IITA to NRCRI on 09 October, 30 October, and 02 December 2015. The IITA team comprising the Deputy Director General (Partnerships and Capacity Development); IITA Project Leadership team; Head, IITA Project Administration Office; Head, IITA Capacity Development Office; and the M & E consultant formulated a draft Transition

Plan of Action in the last quarter of 2015. The plan comprises reversal of leadership roles, fiduciary responsibilities, handover timelines/dates, trainings, and who does what and where with a budget. The final draft transition Standard Operating Procedure (SOP) is being reviewed presently by all parties involved.

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 Monitoring and Evaluation (M&E) consultant on the Project together with an M&E team developed a logframe for the Project to help the team track the activities and progress being made. They also conducted monitoring visits to the Project partners 6-11 July 2015. The IITA Project Management team also visited and had meetings with key officers of collaborating institutes – NRCRI, UAM, and FUNAAB as well as the Director General of Standards Organization of Nigeria (SON) — the regulatory agency responsible for standardization and safety of imported products in Nigeria. An MoU was also signed between IITA and SON.

Key Milestone: Baseline Assessment

M & E Baseline Survey was conducted at project locations as follows: 21 – 22 October (UAM), 26 -30 October (UAM), 2 – 6 November 2015 (FUNAAB). The report is under review at the M&E Unit of IITA.

Output 5: A proactive PR approach is applied and effective messaging on integrated weed management strategies is created and shared among stakeholders.

Throughout the year, the Project consistently developed and disseminated messages on the activities of the Project via television, newspapers and other social media platforms. Working with the three Communication Focal Persons, the Project maintained a good public image by documenting key events using unbiased approach. Furthermore, the web portal was built with a "Contact Us" page that provided two-way communication between the Project team and the public.

L-R: Alfred Dixon (IITA), Julius Okonkwo (Executive Director, NRCRI), and Kenton Dashiell (IITA Deputy Director General, Partnerships & Capacity Development) have been discussing the transition of Project leadership to NRCRI

Cassava Weed Management Project
in the News
2015

DAILY TRUST

IITA Cassava Weed Management Project signs MoU with SON

World Food Day: IITA Cassava Weed Management Project Records Another Feat

New Telegraph

Weed control: IITA engages extension partners

TheGuardian

Tackling weeds and making a difference in the lives of women

Africa Science News Service

Nigeria: IITA's Cassava Weed Management Project Signs MOU With SON