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Community based Integrated Management of Enset Bacterial wilt Through Collective Action in Hallo Hartume, Gedeb

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Abstract: ***Enset bacterial wilt disease caused by Xanthomonas campestris pv. musacearum (Xcm) was found to be remained the most widely destructive, distributed and severe threat to enset (Ensete ventricosum) production in Gedeb woreda. In the assessed area high disease incidence of 79-100% was recorded and considerable enset plants were damaged which desired intervention with appropriate control measures. To avert this problem, collective based integrated enset bacterial wilt management was intervened in Hallo Hartume Kebele of Gedeb Woreda highland between 2014 and 2016 cropping seasons. Under this study, suitable bacterial wilt control events include sanitary control measures, improved cultural practices, disease free and resistance/tolerant enset clones were demonstrated and implemented in an integrated manner (IDM). IDM intervention was done through subsequent awareness creation trainings of farmers, respective and representative partners on the IDM followed by mass motivation and mobilization. Task Force/Command Post at benchmark and district/woreda levels were formed, which was played a primary role in mass motivation, mobilization and IDM technologies promotions. Enset farming community views on the traditional BW disease natural behaviors and control measures have been noticeably changed trainings and practicing packages of IDM. About 89.33% of farmers in the targeted area were aware and adopted IDM; as a result BW disease problem was reduced to 21.30 % and many of farmers were convinced about effectiveness of the IDM through collective action. In addition, at the end of the study, enset clonal diversity was also increased by 26.92%.***

Keywords: *Xanthomonas campestris* pv. *Musacearum, Ensete ventricosum, Community*

1. Introduction

Enset bacterial wilt (BW) caused by *Xanthomonas campestris* pv. *musacearum* (Xcm) is a vascular disease that resulting in yellowing and wilting of leaves, and finally collapsing of the entire plants. It is the most devastating as it kills enset at all growth stages and serious disease in major enset growing areas of the country. BW can damage whole plant system, and usually maximum yield losses of up to 70% will occur (Ashagari, D., 1985). In the early 1960s the prevalence of the causal agent (*Xcm*) was reported as a new outbreak in some enset and banana grown areas of the south western part of Ethiopia (Yirgu D. and Bradbury J.F. 1974). In the beginning the disease did not draw any attention likely the incidence/severity was not serious as it occurs at present time. Since 1980's and then reports started to appear indicating that the disease is becoming a big challenge of the enset production in all enset growing areas and recognized as an important disease that affects enset production and productivity.

The recent systematic survey studies indicate that BW is increasing in severity and distribution in most of enset growing agro-ecologies (Anonymous 2013); causes losses up to 100%. Although, BW disease is present in all enset growing areas throughout the year its incidence and severity is high at mid to higher altitudes and also at off set of rain than the lower altitudes and during dry season. Since the disease is easily transmitting, the problem worsens in most of the enset grown areas. According to Anita et al. (1996) and Million et al (2003) the area under enset production is reducing from time o time due to BW damages (Shiferaw T., 1998, Tsegaye B., *et al.* 1989 and Million T., *et al.* 2003). BW disease is also fond to attack wild enset plants in the forest, South-Western Ethiopia (Temesgen, A., *et al* 2004).

The prevalence, severity and distribution level of BW diseases tend to vary from one enset growing area to the other; depending on various conditions include type of enset clones, environments, and the most possibly farmers' attitudes and perceptions towards its management practices. In the last years various research efforts were done to manage enset BW by Agricultural Research Centers including Hawassa. Sanitary control measures, improved cultural practices (Yirgou and Bradbury 1974) and the use of disease free and resistance/tolerant enset clones (Fikre and Gizachew, 2007) were recommended as an effective control methods of the disease. Some farmers use sanitary control measures such as uprooting and discarding BW infected enset plants, use of uncontaminated farm tools and fencing to check enset eating animals' movement into enset fields. Some farmers also grow relatively resistance/tolerant enset clones and use cultural practices such as tillage and spacing, crop rotation and manure. Nevertheless, many farmers do not use the recommended practice properly because of a little perception about the effectiveness of these methods and traditional believes. With regards to that implementing of improved BW management measures in an integrated manner understood to be effective and successful control option. Therefore, this study was carried out with the objective to scaling up an integrated disease management (IDM) through collective action at community level.

2. Materials and Methods

The case study was conducted in Hallo Hartume Kebele of Gedeb Woreda highland between 2014 and 2016 cropping seasons and the location was selected because of the crop was damaged seriously by BW disease. Under this study, suitable bacterial wilt control events include sanitary control measures, improved cultural practices, disease free and resistance/tolerant enset clones were demonstrated and implemented in an integrated manner through subsequent awareness creation trainings of stakeholders.

2.1 Description of the study area

Hallo Hartume is the largest Kebele found in Gedeb woreda of Gedeo zone; situated at elevations between 2345 to 2786m, latitude 06'16.508-N and 038'24.705-E that has cool weather conditions. The mean annual rainfall is about 1700mm with minimum and maximum of 850 and 2000 mm, respectively, that lasts for 5-6 months and an average annual temperature is 21^{o}C; with minimum and maximum temperatures of 8 and 27^{o}C. The major soil type includes Black-brown. In the locality, enset is a base of farming system of small scale agriculture production; occupied an area of about 47% in the cropping system and it is the most staple food and source of income. Apart from enset, maize, barley, faba bean, field pea and wheat are the major growing crops in the kebele.

2.2 Interventions steps and approach

i) Field survey

Pre and post intervention base line information was collected to understand farming community's perception towards the BW behavior, causal agent, means of dissemination and traditional knowledge to control the BW disease. In order to substantiate the results of a systematic survey was carried out using structured questionnaire directed on randomly selected of 100 households in the study benchmark. Based on enset production potential, the data on disease incidence and severity, type of enset clones and their reaction to BW were also collected from randomly selected out of the representative households. Disease incidence was considered as the number of infected enset fields divided by the total number of assessed farms (Sharma, 1992).

ii) Discussions meeting and planning

The discussions were held with the respective and relevant officials and partners at Gedeb district/woreda administrative and Hallo Hartume Kbele levels on the objectives of the study, stakeholders' participation, mass mobilization and logistics during the collective action. Followed by discussions participatory action plan was prepared.

Figure 1: *Discussions and action plan meetings at kebele and woreda levels*

iii) Training

In general at enset farming community level there was inadequate information on the BW disease causal agent, transmission mechanisms, and misunderstandings of the effective's management practices. With these regards, awareness creation trainings have been given to key partners about the BW disease towards control measures. In addition packages of IDM practices was prepared and has been given to trainees as a procedures and cares to be pursued while collective action intervention takes place at district/woreda and village levels.

iv) Task force formation and by- law set up

As a command post task force (TF) was formed at benchmark and district/woreda levels, to enhance and support BW eradication campaign through collective action. The detail of TF responsibility and accountability was set up during the partners' workshop which has been held at zonal level. The members of TF were also been selected from communities and partner as all participants were agreed. The TF number (7) and composition were also decided at the partners' workshop. The IDM implementation calendar was done by TF, Kebele Leaders, model farmers and Technical Team accordingly. A locally prepared, respected and approved rule (by-law) was also set up to direct and adjust if any stakeholder who violate the agreements regarding BW disease eradication activities within the community.

v) Community mobilization and implementation

Enset BW disease eradication campaign through collective actions requires farming community mobilization. Mass mobilization towards BW management practices was performed after sensitizing and trainings of partners as well as farming community. In collaboration with Technical Team

from Hawassa Agricultural Research Centre, FT was played a leading role in mass motivation, mobilization and IDM technologies promotions. In addition, the basic procedures that should be followed by the farming communities and stakeholders while implementing BW control measures were demonstrated to farmers and development workers at BW infected enset farms.

3. Results and Discussion

3.1 Benchmark selection and field survey

Hallo Hartume is the largest *kebeles* in Gedeb district/woreda with population of 1178 among which 48% were women. In this area enset is produced at large by small scale farmers; occupies an area of about 47% of the farming system and it is the most staple food and source of income. In general, Gedeb including Hallo Hartume Kebele is known to produce nationwide-class quality *kocho* for local markets as well as Addis Ababa. In the farming community enset products such *Kocho* and fiber (Fig 2) are found an outcome farming business especially young women and men benefit of the enset by making money, although produced basically for home consumption.

Figure 2: Enset products business in local market, GEDEB

A total of hundred enset fields were randomly selected and surveyed for the determination of BW incidence and distribution. Among which in 92 enset fields' high incidence of 100% was recorded being damaged an average of about 11 enset plants per field, while in only few fields relatively low incidence was observed (Table 1). An average BW incidence was also high (93%) in assessed enset fields. As results, BW disease was the most important and serious challenge for the enset production and productivity. Realizing these situations, IDM has been demonstrated and scaled up in the benchmark through collective action.

Table 1: Pre-intervention WB wilt infected field and disease incidence

Infected field			Average infected enset/field
Category	(%)	WB Incidence (%)	
High	77	100	12
Moderate	15	100	5
Low	8	79	1

In Hallo Hartume kebele, small-scale farmers grow and maintain different/mixed enset clones in the same field/homestead. According to local names given by farmers, nineteen enset clone types having various value were recorded, although cultivated mainly for *kocho* (the bulk of the fermented starch obtained from the mixture of decorticated leaf sheath and granted corms) *bulla* (squeezed and extracted starch from *kocho*) and fiber (by-product of enset, which left after decorticating the leaf sheath) products (Table 2). Unlike other field crops, growing diverse enset clones in the same field/plot is a direct reflection of the number of values include secure and assure the stable food in times of unfavorable environmental conditions (Adimasu , 2002), early maturity (personal communication) and make available wide range of resistance/tolerant to the BW disease.

During the farmers' group discussions and field assessments, it was observed that over 84% enset clones were found susceptible to Xcm. Among the enset clones 'Genticho and Toracho' enset clones were the most dominant, distributed and have relatively better tolerance to BW disease attacks in the surveyed area conditions. In addition these clones are also very popular and known for high *kocho* plus fiber yields. Based on farmers demand 6 released (for kocho yield) enset suckers and one enset clone 'Maziya' known to resistance/tolerate against BW (Fikre H. & Gizachew W. 2007) were introduced as a clean and resistant planting materials. A total of 4,000 new suckers of Maziya and 25 suckers each of 6 released enset clone were produced and transplanted and demonstrated in farmers training center (FTC) and model farmer fields for further multiplication and distributions to the farmers. Consequently, at the end of the study, diversity of enset clones increased by 26.92%.

Traditionally, in the enset farming communities, an ordinary household keeps about 200 to 300 matured (ready to harvest) enset plants in his homestead plot which comprised of five to ten types of enset clones. Farmers keep not only different enset clones in the same field but also different growth stages (suckers, young and matured) of enset clones to assure sustainability and continuity of enset farming in their localities (Fikre and Alemar, 2017). This trend is also true in case of Hallo Hartume farming community; farmers intend for more disease resistance/tolerant, adaptable and high-yielding enset clones to minimize the risk due to BW disease attacks and secure food and income.

Table 2: Enset clone types, uses and responses to Xcm at Hallo Hartume conditions

No.	Enset clone	Major use	Response to Xcm	No.	Enset clone	Major use	Response to Xcm
1	Genticho	*Kocho*	Tolerant	14	Mike	Medicinal	Susceptible
2	Niffo	*Kocho*	Susceptible	15	Trungo	*Kocho*	Susceptible
3	Kerasse	*Kocho, Amicho*	Susceptible	16	Keltate	*Kocho*	Susceptible
4	Astarra	Medicinal, *Amicho*	Susceptible	17	Harume	*Amicho*	Susceptible
5	Denbelle	*Kocho*	Susceptible	18	Keke	Medicinal	Susceptible
6	Munda	*Kocho, Amicho*	Susceptible	19	Addo	*Kocho*	Tolerant
7	Gatrra	*Kocho*	Susceptible	20	*Endale	*Kocho*	Tolerant
8	Fililla	*Kocho*	Susceptible	21	*Gewada	*Kocho*	
9	Korkoro	*Kocho*	Susceptible	22	*Kelisa	*Kocho*	
10	Toracho	*Kocho*	Tolerant	23	*Mesenna	*Kocho*	Tolerant
11	Agina	Amicho	Susceptible	24	*Yanbulle	*Kocho*	
12	Dimoye	*Kocho, Amicho*	Susceptible	25	*Zereta	*Kocho*	
13	Fonoke	*Kocho, Amicho*	Susceptible	26	*Maziya	*Kocho*	Tolerant

**Newly introduced enset clones*

3.2 Farmers perception and attitude on the BW disease

Over the long cultivation periods, farmers have a considerable indigenous knowledge of enset production system, clonal selection for various values. However, the initial knowledge of farmers on the bacterial wilt disease causal agent, mode of transmission and control measures has been negligible. During the farmers' group discussions, it was observed that farmers have a variety of traditional believes which they think, helps to reduce the BW disease incidence. Some of them were dusting of dried and crushed camel dung on infected enset plants, planting '*Kulkual'* around the infected enset, wrapping infected plant with its leaves and leaving in the field (Fig 3), roasting coffee in the enset fields etc. Some of farmers practice smoking of bone, rubber, skin, horn etc. in the fields for the BW control. Actually these traditional approaches to treat BW disease didn't reduce the infectivity and at present most of the farmers doubtful on the helpfulness of practicing these traditional events in control of BW disease.

Table 3: Farmers traditional knowledge on the bacterial wilt natural behavior and control measures

Description	% of farmers practice
i) Indigenous knowledge	
WB symptoms identification	98.3
WB causal agent	0.85
Mode of dissemination	
• Air	77.0
• Contaminated farm tools	43.3
• Animals move in infected field	47.4
• Not known	21.7
i) Control measures	
▪ Uprooting and discarding	31.6
▪ Care of farm tools	34.2
▪ Crop rotation	13.2
▪ Wrapping infected plants	48.8
▪ Use of drying and dusting camel dung	17.4
▪ *Kulkual* planting around enset	9.5
▪ Fencing	15.7
▪ Smoking different substances	43.6

Of course few model farmers were found to care of contaminated enset farming tools, uprooting and discarding of infected enset plants. Severely infected enset fields were also replaced by other crops as rotation . Some of the farmers in the community were also fenced enset fields to prevent the entrance and movement of enset eating animals which were suspected to attribute the transmission of the wilt pathogen (Table 3). Accordingly they enable to minimize BW incidence to some extent.

Figure 3 *Wrapped…*

Figure 3: *Wrapped infected plants*

3.3 Awareness creation

Awareness creation training is believed a vital input in an extension campaign through mass mobilization, to build up basic knowledge, strengthen the capacity of partners and build trust and confidence for changing of people's perception and attitudes. Moreover enset BW disease control is easier when local communities aware and considers as their own task and practice recommended control measures collectively. With these regards, awareness creation trainings were given for representative stakeholders that have direct and/or indirect influence on the mass mobilization towards collective action. The trainings were designed in such a way that all stakeholders to be represented and participated and hence diffuse the enset BW management technologies information to a maximum possible range. Accordingly, subsequent trainings on improved enset production and bacterial wilt management practices have been given for a total of 124 representatives, respective and relevant trainees selected from district/woreda and kebele. Participants of trainings included leaders/officials of woreda and kebele, extension service experts, community based organizations (CBO) leaders such as religion, *idir*, *iqub*, respected local elders and elites, model farmers, school director, women and youth affairs and mass media.

Training materials such as manuals (500), leaflets (1000) and posters (100) describing improved EBW management options and enset production technologies were prepared and distributed to stakeholders and farming communities. As a result, community views especially on the traditional BW disease causal agent, mode of transmission and control measures have been noticeably changed and tended to apply IDM. Sensitization, inspiration and mass mobilization trainings were found very useful approach for the collective action based BW wilt disease management. Similarly, a recent study reported by Z. Yemataw *et al.* (2016) specifies the importance of community mobilization and awareness creation for the management of enset BW disease.

3.4 Enset bacterial wilt eradication campaign/implementation

At the inception phase of intervention, a lot of farmers and experts showed unwilling response /behavior to apply IDM in the targeted locality. According to the initial discussions, the reasons are expectation and demand for chemical control measure and assuming that IDM without chemicals is labor consuming and tedious. Regarding the use of chemicals, for the control of enset BW, it is not yet investigated well, because of chemical control method is likely infeasible for BW control in enset. Obviously, chemicals especially bactericides are dangerous and complex to handle and not simple to use at small scale enset farmers, leave poisonous residues to affect human health and environment.

After subsequent sensitizations, awareness creation trainings including demonstration of BW control measures, farming community understood the scientific approach and farmers develop trust and knowledge on the effectiveness IDM and later on started to practice through collective action (Table 4). The reasons for the importance of collective action is that uprooting and disposing of infected enset plants from enset fields into pits demand more labors and times that it is very difficult/heavy task for some households having small size of family. So there were numerous governmental and cultural organizations include FRG, Farmers Development Group, One to Five Unit, CBO, etc. identified as an effective form of collective in the community that have been actively involved in an eradication campaign against BW. Even school children (boys and girls) and school staffs as whole have been discussed on the BW issues and interacted during community mobilization towards IDM interventions with their parents. Moreover, school children were played role in conveying messages to their parents from FT regarding the BW eradication campaign.

Figure 4 *Destruction & disposal of diseased plants*

Implementing of sanitary control measures such as uprooting and burying in dug pits outside the enset fields and/or burning with fire (Fig. 4); disinfecting farming as well as *kocho* processing tools with fire flame, used during collective action of BW eradication; along with replanting of disease free and BW resistance/tolerant enset clones in place of removed infected plants were among the major activities practiced. Because of the permanent nature of enset plantation**,** it is difficult to apply crop rotation on the whole enset field. In

highly infected (at hotspot) fields partial crop a rotation at least for one year was also applied (Fig 5).

Figure 5 *Partial rotated fields*

3.5 Participatory surveillance and evaluation of collective action

At the end of the study, post intervention assessments were carried out from 76 randomly selected farmers' enset fields using checklists, to ascertain farmers' attitude change and the effectiveness of community based integrated management of BW through collective action at the respective locality. Participatory monitoring and evaluation was executed by TF along with technical committee (enset research project team), development agents, extension experts, model farmers (men and women), and local CBO leaders. Being compared of pre and post IDM intervention through mass mobilization and collective actions, the survey and surveillance results were summarized and presented in Table 4.

Table 4: Comparative surveillance results of farmers' knowledge and perception on the BW disease

Description	Pre-intervention (%)	Post-intervention (%)
Farming community knowledge and perception on the BW disease;		
· Symptoms identification; · Causal agent; · Mode of transmission;	94 0 29	100 85.33 98.00
Use of BW disease management methods; · Sanitary control measures · Cultural practices · Disease free and resistance/tolerant clones · IDM · Chemical control expectation	 20 67 32 0 100	 96.00 85.73 94.33 97.00 5.33
Enset clonal diversity increased by	-	26.92
BW management through collective action;	0	100
BW incidence;	93	21.30
Farmers used newly introduced enset clones;	0	95.00
Farmers adopting IDM;	5	89.33

There were considerable changes of a farming community perception and attitudes after subsequent sensitization, mass mobilization, awareness creation trainings and demonstration of integrated control measures. Farmers and relevant experts build up a basic knowledge and trust on the bacterial disease management practices collectively, strengthen the competence of local partners on the integration of the best control components application. Majority of the farmers (89.33%) aware about BW disease behavior and adopt effectiveness of IDM in checking BW disease. As a result the infectivity of BW disease was diminished at benchmark. Pre- intervention of IDM, the disease incidence was high (79-100%) and it was minimized to 21.30% after implementation of IDM through collective action.

4. Conclusion and Recommendations

BW disease is fond the most biological constraint that has been affecting enset production and productivity in Hallo Hartume locality. Since the disease is easily transmitting, the problem was worsens in most of the enset fields. Lack of awareness, and varying perception and attitudes have also been influenced farmers' behavior in solving of the BW issue. Farming community awareness and scientific views on the BW disease causal agent, mode of transmission and control measures was negligible. In addition, the expectation of chemical control method was limiting farming community from implementing of non-chemical control measures; being developed resistance/negative attitudes about the effectiveness of the sanitary control measures and cultural practices.

However through subsequent awareness creation trainings, farmers and experts perceptions and attitudes on the natural behavior of BW disease and about its management practices were considerably changed. Overall in the study area, farmers build up trust and confidence in the application and effectiveness of IDM (non-chemical control method) in their area. According to the results of this study about 89.33% of the farmers adopted IDM; as a result BW disease incidence was reduced to 21.30 % and many of farmers were convinced about effectiveness of the IDM through collective action.

Participatory based IDM through collective action approach is found a viable option for the successful and sustainable control of enset BW, as it involves suitable control components and different partners along with farming communities. Implementing of IDM under real enset farming community conditions in collaborations with responsible partners and assistance of local administrative and CBOs leaders is the most advisable approach at hand, believed enable to attain successful and sustainable results. In addition it was recommended that all farmers in the area should maintain strict and procedural application of IDM on regular basis to reduce BW infection under low level; subsequent awareness creation trainings of farmers on the exact and practical use of IDM is also very vital approach.

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