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# Integrated Late Blight Management for Potato: The Case of FFS and FRG in Central Highlands of Ethiopia

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**Abstract**
Potato is the fastest growing staple food crop and source of cash income for smallholder farmers in Ethiopia. Potato production was almost impossible during the rainy season in the central high lands of Ethiopia due to potato late blight diseases. Recently, the introduction of late blight tolerant varieties changed the trend and farmers were able to overcome their food insecurity problem during the long rainy season. A participatory potato technology development and dissemination process was undertaken in the central highlands of Ethiopia in four districts of Oromia regional states using Integrated Disease Management /IDM/ for Potato late blight disease. A total of thirteen FFSs and thirty six FRGs were organized to conduct the activity. Thus, participatory research methods of through farmer's field school (FFSs) and farmers research group (FRGs) were organized to evaluate and promote the technologies. The number of participant farmers in each FFS and FRG included an average of 25 and 15, respectively. The experiment was laid in split plot design putting fungicide spray as main plot and potato clones as sub-plot. To see the difference in their reaction to late blight disease a fungicide (Ridoml MZ 62.3% WP) was sprayed twice at a rate of 2 kg/ha. The analysis of variance (ANOVA) revealed that there was a highly significant difference ($P<0.001$) on yielding ability among the clones evaluated. Thus, mean separation test was carried out using least significance difference (LSD) test procedure. The highest yield was obtained from the clone CIP-392650.516 which was significantly different from all the varieties tested. Clones, Kp–90134.2 and CIP–386423.13 gave a non-significant yield difference. Unpaired t-test revealed that there was a significant difference between the two participatory research approaches, FFS and FRG, in respect to total yield. A higher yield advantage was obtained by using FFS approach when compared to FRG approach. On the other hand, when comparing the yield values obtained in sprayed and unsprayed plots separately, the clone CIP-392650.516 in sprayed condition gave the highest significant yield ($P<0.05$) under sprayed and unsprayed conditions. In general, the FFS approach helped the farmers' to acquire more knowledge and equipped them with technical know-how on the proper management of the potato fields which was reflected by the superior yield of the varieties.
**Keywords**: Farmer field school, Farmer research group, Potato IDM, Late blight, AUDPC and Participatory research

## 1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops worldwide. It ranks third after rice and wheat in terms of human consumption (FAOSTAT, 2015). Among root and tuber crops, potato ranks first in volume of production and consumption, followed by cassava, sweet potato and yam (FAO, 2008). Annual world production of potato is about 330 million metric tons from 18,651,838 ha area coverage and in Africa total production is about 17,625,680 tons from total area coverage of 1,765,617 ha (Isreal *et al*., 2012). In Ethiopia, total area coverage of potato is nearly 0.18 million hectare from which 1.62 million ton is harvested (CSA, 2014). According to Yilma (1991), about 70% of cultivated agricultural land of Ethiopia is suitable for potato production. Despite high potential production environments and marked growth, the national average potato yield in farmers field in Ethiopia is only 11.1tha$^{-1}$, which is lower than the experimental yields of over 38 tha$^{-1}$(Woldegiorgis, 2013; FAOSTAT, 2015), which is very low compared to the world average of 17.6 tha$^{-1}$ (Isreal *et al*., 2016). The main contributing factors for under production and utilization of potatoes are lack of high yielding and diseases tolerant varieties, unavailability of quality seed and poor agronomic practices such as optimum nutrition and irrigation etc (Hirpa *et al*.,2013).

In Ethiopia it is the fastest growing staple food crop and source of cash income for small holder having high potential for food security due to its high yield potential and nutritional quality tuber, short growing period, and wider adaptability (Tewodros *et al*., 2014). Potato late blight disease which is caused by oomycete, *Phytophthora infestans* (Mont) de Bary is the major bottleneck that devastating of potato worldwide (Hijmans *et al*., 2000) in potato production in Ethiopia (Bekele and Yaynu, 1996). Yield losses due to the late blight disease are attributed to both premature death of foliage and diseased tubers (Bekele and Gebremedhin, 2000). The disease was reported to cause yield losses ranged from 31-100% in Ethiopia depending on the variety used (Mesfin and Gebremedhin, 2007). The disease occurs throughout the major potato production areas and it is difficult to produce the crop during the main rainy season without chemical protection measures (Borgal *et al*., 1980). Most farmers had stopped using their old local potato varieties due to the devastation of their plot by the late blight disease. However, use of fungicides in controlling the disease was found to boost potato yield in various East African countries (Mesfin, 2007). According to Habtamu *et al*. (2012) the profound ability of the disease to reach an epidemic level within short periods, the inadequate efficiency of cultural practices to reduce high level of disease severity, and rapid development of resistance to fungicides and breakage of plant resistance in potato cultivars within short period of time have made integrated use of different disease management strategies very essential in late blight management. Namanda *et al*. (2001) stated that the combined uses of fungicide and tolerant/resistance varieties have evolved as one of the most important options in the management of the disease. The authors described that integrating fungicide applications with varieties by choosing the best fungicide-cultivar combinations improves the durability or sustainability of the released potato varieties in the potato production system. This is particularly important in developing countries such as Ethiopia, where the setup of efficient and sustainable breeding programs for potatoes are inadequate and farmers can't afford to spray fungicides frequently to boost their potato yield. Therefore, integration of fungicides with cultivars has been commonly practiced for sustainable production of potatoes in most developed world (Namanda *et al*., 2001).

Production of potato in the highlands of the country was almost impossible during the main cropping, long rainy season due to late blight disease. Recently, the introduction of late blight resistant varieties released by the research institutes totally changed the trend and areas where production of potato was stopped had restarted producing sufficient amount of potato tubers and farmers were able to overcome their food insecurity problem during the long rainy season and generate income. Along this line, complementing of the elite potato materials with limited amount of fungicide sprays was one of the strategies to tackle the late blight epidemics. But some farmers can't afford to spray frequently when the late blight disease pressure is very severe. Hence, the need to incorporate varietal resistance along fungicide spray in a very wise manner as to be safe to the users and the environment was envisaged. Intensive fungicide application is costly and the products may not always be available to resource poor farmers and also create emergence of resistant *Pi* strains as the pathogen can easily adapt to the fungicide used repeatedly. Consequently, the use of an alternative, less expensive and less polluting method, such as the planting of tolerant/resistant varieties, field sanitation and selection of clean seeds may be sound strategies for a sustainable management of potato late blight disease (Fontem, 1998). Morse and Buhler (1997) described that Integrated Disease Management (IDM) is often thought as a cost effective, environmentally friendly, and appropriate technology for small-scale farmers, it is also recognized as being inherently complex and knowledge intensive.

In Ethiopia, despite the fact that well established IDM technologies for crop such as potato is in place, adoption rates remain extremely low due to poor extension system. It is now clear that the problem is not only due to unsuitable or lacks of technologies but also inappropriate extension methods. Researchers had undertaken various research activities on-station and then pass on technological 'recipes' or 'packages' to the extension workers to provide developed technologies to the farmers. This is done without letting them know the underlying principles. As a result, these innovation or technological 'packages' were not disseminated as envisaged. Therefore, a participatory potato technologies development and dissemination process was undertaken in the central highlands of Ethiopia for the last two decades as technology popularization. The methods used to disseminate the available technology included farmer field schools (FFSs), farmers research groups (FRGs), on-farm variety adaptation trials, informal seed production and training. The focus of the participatory research was on exploring, developing and implementing farmers' responsive research and extension approaches. Therefore, in order to generate and transfer suitable technologies, farmers should be involved right from the identification of the problems, through testing of potential solutions and the finalizing evaluation of the technologies.

The complex situation in potato late blight disease calls for development and use of integrated approach to crop management. The assumption underlying the concepts for integration presented in this study is that the effects of different control measures are complementary and additive. Integration of two measures was considered, viz, genotype resistance to late blight and reduced fungicide application. Hence, the major objective of this research is, to identify an appropriate participatory research methodology that could minimize yield loss caused due to late blight disease through using integrated disease management option.

## 2. MATERIALS AND METHODS

### 2.1. Description of the study site

Integrated Disease Management for Late Blight (IDM-LB) was conducted in two zones of Oromia region, central highlands of Ethiopia at four districts namely; Jeldu, Dendi, Wolemera of West Shewa Zone and Dagem districts of North Shewa Zone were selected for the farmer level experiment based on importance of the crop in these areas. All the districts are characterized by mixed crop-livestock farming systems mainly representing highland agro-ecologies. Jeldu, Dendi and Wolemera are located at a distance of 130, 100 and 45kms West of Addis Ababa, respectively while Dagem district is located at a distance of 126 kms Northwest of Addis Ababa. During the study a participatory approach through Farmers Field School (FFS) and Farmers Research Group (FRG) were used to promote and evaluate IDM-LB. A total of thirteen FFSs and thirty six FRGs were organized and the number of participant farmers in each FFS and FRG were on average 25 and 15, respectively. Therefore, a total of 327 and 183 farmers took part in this activity through FFS and FRG approaches, respectively.

**2.2. Selection of Participant Farmers**

The farmers that participated in FFS and FRG were selected by contacting Kebele (the smallest administrative unit in the country) leaders in collaboration with development workers of district agriculture and rural development office. Initially invitation of meeting was announced by chairman of the Kebele to the farmers in the village and then the facilitator explained the details of the FFS and FRG process to the farmers. Then, the farmers attending the meeting were invited to register voluntarily at no cost following the meeting after they clearly understood the objectives and importance of FFS and FRG for learning and research. After the process of registration, some informal meetings were carried out with registered farmers to select the place where the experiment to be conducted. The participant farmers were responsible for the management of the trials from planting to harvesting and they have also assessed the genotype performance (i.e. growth, disease resistant and yield).They also listed and ranked based on the most important criteria used in selecting varieties for production. Farmers also provided qualitative information of the genotypes tested and, hence, their acceptability.

**2.3. Description of PR Methodologies**

**2.3.1. Farmers Field School (FFS):** is a participatory approach with high farmer involvement and higher facilitation role of the facilitator. It involves the collegial and self-initiated types of participatory research. Field schools are based on adult education principles that stress the importance of learning through hands-on activities, with the field itself the learning laboratory (Braun *et al*., 1997). Rather than a responsible researcher, a facilitator acts as guide and mentor to steer participating farmers through the FFS learning process. There were 12 periodic field sessions (Table 1) that has been given following the phenology of the crop. The role of the facilitator is to facilitate the discussions during field sessions and farmers exchange ideas and discuss it among themselves regarding disease symptoms and crop performances and also took their records (Table 2).

**2.3.2. Farmers Research Group (FRG):** is a participatory approach with lower farmer involvement and lower frequency of facilitation by the facilitator as compared to FFS approach. This method does not employ field sessions as a training tool. The farmers do not influence the treatments and the group does not necessarily have a structure, and only participate on specific occasions such as cultural practices. In this approach farmers discuss about the crop by themselves and raise questions for the facilitator. In this participatory research approach the facilitator acted as a supervisor and interacted with the farmers less frequently.

**Table 1. Field sessions on IDM-LB and the time spent**

| Session | Session title | Time spent (hrs) |
|---|---|---|
| 1 | Introduction to the Farmer Field School (FFS): Initial Diagnosis of Knowledge of the Participants on Diseases and Insects of Potato and the Practices of Control measures | 2-3 |
| 2 | Knowledge, Attitude and Practices of participant farmers on Late Blight, Potato tuber moth, Cut Worm and Other Insects Control practices in Potato Production | 3 |
| 3 | Basic concepts of experimentation: Randomization, replication and Sampling. | 2 |
| 4 | Potato seed quality: Selecting, handling and planting clean potato seed. | 3 |
| 5 | Crop management and its Application to Potato: Weeding, Hilling/ ridging and Soil fertility management | 2-3 |
| 6 | Symptoms and Diagnosis of Late Blight and Other Potato Diseases | 3 |
| 7 | Late Blight Disease Development and its relation to the Environment | 3 |
| 8 | Fungicide Application: Nozzle Selection, Spray Equipment Calibration and Safety Precautions in the Use and Storage of Fungicides | 2-3 |
| 9 | Reaction of potato varieties to late blight under fungicide management strategy | 2 |
| 10 | Insect Management in relation to Potato Production | 2 |
| 11 | Positive Selection and other harvest Considerations | 2-3 |
| 12 | Analysis of Costs and Benefits of the Experiments | 1-2 |

**2.4. Treatment and experimental design**

The experiment was laid out in a split plot design with three replications. The treatments were fungicide in the main plots and five elite potato clones and one local at sub-plot level. An inter row spacing of 0.75m and an intra row spacing of 0.3m were used in a plot size of 22.5 $m^2$. The potato clones included in the study were; CIP–392640.516, CIP–392650.516, CIP–386423.13, KP–90134.2, Standard check (Jalenie) and Susceptible check (local). Fungicide used was Ridoml MZ 62.3% WP and sprays were made twice during the growth period of the plant. The first spray was conducted at the first symptom of late blight disease on the susceptible check while the latter was made at 20% disease severity on the unsprayed susceptible check. Others cultural practices were done in the same practice as Holetta Agricultural research center recommended practice for potato production. During the implementation of the experiment, responsibility was shred among the stakeholders and roles and responsibilities of the facilitators and the participant farmers were described (Table 2).

**Table 2. Roles and responsibilities of FFS Facilitators and Participant Farmers**

| Facilitators | Participant Farmers |
|---|---|
| Organization of FFS and FRG | Allocation of experimental plots |
| Giving orientation or facilitation to participant farmers on the activities | Management of the experiments |
| Designing the experiments with participant farmers | Undertake cultural practices |
| Implementation of experiments with participants | Construct potato storage structures |
| Official opening of the field schools | Evaluate the experimental results |
| Run Weekly field sessions to FFS participants | Participation in data collection |
| Collecting data of the experiments | Participate in weekly sessions |
| Evaluation of technologies with farmers | |
| Analyze the collected data and prepare progress reports | |

### 2.5. Data collection and Analysis

Data on plant emergence, plant height, and number of main stem per hill, plant vigor, number and weight of tubers, taste preference, cooking ability and color preference were collected. Besides the agronomic data, disease data was collected regarding late blight severity in each experimental plot at 30, 50, 70 and 90 days after planting. These data were interpreted into area under the disease pressure curve (AUDPC) using the formula of Campbell and Madden (1990). Yield data were analyzed using SAS 9.2 software (SAS Institute Inc. 2001). During the vegetative stage of the crop an evaluation by a group of researchers were organized and field evaluation was made regarding the technologies being tested. Discussions were made with the participant farmers about the field performance of the technologies. On the other hand participant farmers have periodically evaluated the technologies at different growing stages of the crop and drew information concerning the appropriateness of the technologies.

## 3. RESULTS AND DISCUSSION

### 3.1. Participatory Approaches (FFS Vs FRG)

The time spent for IDM-LB activities in the FFS approach was presented in Table 1. IDM-LB potato was evaluated at Jeldu, Dendi, Wolmera and Degem district, both through Farmers Field School (FFS) and Farmers Research Group (FRG) participatory approaches. During the study, a total of 13 FFS and 36 FRG have been organized to undertake the activity. The number of participant farmers in each FFS and FRG was on average 25 and 15, respectively. Therefore, a total of 327 and 183 farmers took part in this activity through FFS and FRG approaches, respectively. Among the total 759 farmers who participated in the participatory experiment in IDM, 327 of them (43%) hosted FFS while 432 (57%) hosted FRG experiment.

### 3.2. Evaluation of elite potato clones

During this activities farmers participated from site selection to harvesting and evaluation of elite potato clones for their late blight reaction under sprayed and unsprayed conditions. Farmers were given the chance to select potato clones suitable to their conditions based on such criteria as disease resistance, taste preference, cookability and yield. Accordingly, farmer's ranked potato clone CIP–392650.516 the highest yielder and late blight resistant among the tested clones. However, the same variety was ranked as 5$^{th}$ in its taste preferences (Table 3). Moreover, the clone CIP–386423.13 was ranked as 2$^{nd}$ in both taste and yield but 4$^{th}$ in its late blight disease reaction.

**Table 3. Evaluation of potato clones by farmers**

| Potato Clones | Yield Ranking | Taste Preference Score | LB Disease Reaction ranking | AUDPC |
|---|---|---|---|---|
| CIP-392640.516 | 2.76 (3) | 1.06 (6) | 2.17 (5) | 194.7 |
| CIP-392650.516 | 3.76 (1) | 1.92 (5) | 3.56 (1) | 234.1 |
| CIP- 386423.13 | 3.09 (2) | 3.08(2) | 2.52 (4) | 61.3 |
| KP-10934.2 | 2.71 (4) | 2.81 (4) | 2.66 (3) | 43.7 |
| Jalenie | 2.57 (5) | 3.29 (1) | 3.35 (2) | 507.5 |
| Susceptible check | 0.44 (6) | 2.86 (3) | 0.58 (6) | 1776.2 |

***Note:*** *Preference ranking and disease reaction were recorded out of 1–6 scale. A score of 1 is for the best and 6 for the least. Numbers in bracket are ranks based on mean evaluation of varieties.*

### 3.3. Late Blight Disease Severity

Four potato clones, standard check and a susceptible check (local) were evaluated for their resistance towards late blight disease. The least area under the disease progress curve (AUDPC) was recorded for clone, Kp–10934.2 followed by clone, CIP–386423.13 though farmers' gave the best ranking to CIP–392650.516 (Table 3) which was not in harmony with the accumulated late blight disease severity over the whole season.This difference could be accounted to the one time evaluation made by farmers' which did not include from the start of the late blight disease till senescence of the crop. Among the tested potato clones the disease was most severe on the susceptible check (local).

### 3.4. Tuber Yield

The analysis of variance (ANOVA) computed revealed that, there was highly significant difference ($P<0.001$) on yielding ability among the potato clones tested. Thus, mean separation test was carried out using least significance difference (LSD) test procedure. The highest yield was obtained from potato clone, CIP–392650.516, which was significantly different from all the clones and standard and local checks tested. Clones Kp–90134.2 and CIP–386423.13 gave a non-significant yield difference. In addition, the yield difference obtained among CIP–386423.13, CIP–392640.516 and Jalenie were found to be non-significant. The least yield was recorded for the susceptible check in both participatory research (PR) approaches which was significantly different from all the other clones (Table 4).

**Table 4. Mean tuber yield in t/ha of the potato varieties**

| Potato clones | Yield (t/ha) |
|---|---|
| CIP–392650.516 | 35.2**a** |
| Kp- 90134.2 | 33.3**b** |
| CIP–386423.13 | 31.7**bc** |
| CIP–392640.516 | 30.9**c** |
| Jalenie | 30.1**c** |
| Susceptible check | 9.7 **d** |
| CV=29.83, LSD=1.928, α =0.05 | |

**Means in a column followed by the same letters are not significantly different at 5% probability level.*

The yield difference between sprayed and unsprayed potato varieties which were handled under farmers' field school (FFS) and farmers' research group (FRG) were presented in Table 5. Potato clone CIP–392650.516 gave similar yield in FFS and FRG PR methods in unsprayed condition and clone CIP–386423.13 gave the second least yield advantage in FFS approach over FRG approach in unsprayed conditions. Generally, a positive yield advantage was obtained by using FFS approach over using FRG approach. Unpaired t-test revealed that there is a significant ($P<0.05$) difference between the two participatory research approaches, FFS & FRG, in respect to total yield. A higher yield advantage was obtained by using FFS approach as compared to FRG approach (Table 6).

**Table 5. Yield of the varieties over location and years in the two PR methods used**

| No | Varieties/ Clones | Sprayed | | | Unsprayed | | |
|---|---|---|---|---|---|---|---|
| | | FFS | FRG | Yield advantage* | FFS | FRG | Yield advantage* |
| 1 | CIP–392640.516 | 34.9 | 31.6 | 10.2 | 29.9 | 27.0 | 10.7 |
| 2 | CIP–392650.516 | 40.1 | 36.6 | 9.7 | 32.1 | 32.1 | 0 |
| 3 | CIP–386423.13 | 33.4 | 32.7 | 2.29 | 30.7 | 30.1 | 1.86 |
| 4 | Kp–90134.2 | 36.4 | 33.0 | 10.5 | 33.1 | 30.5 | 8.65 |
| 5 | Jalenie | 34.7 | 31.8 | 8.9 | 28.4 | 25.4 | 11.89 |
| 6 | Susceptible check | 13.0 | 11.0 | 18.1 | 8.1 | 6.7 | 20.7 |
| | CV = 29.83 | | | | | | |

** Yield advantage obtained in using FFS approach over using FRG approach (%)*

**Table 6. Mean yield differences obtained in the two PR approaches and Fungicide options**

| Participatory Approaches | Yield (t/ha) | |
|---|---|---|
| | Participatory Method | Fungicide |
| FFS | 29.5**a** | 30.8**a** |
| FRG | 27.3**b** | 26.2**b** |
| t=1.42, α =0.05 | | |

** Participatory method; 1=FFS 2= FRG, Fungicide; 1=Sprayed 2= Non-sprayed;*

As compared to the yield values obtained in sprayed and unsprayed plots separately, potato clone CIP–392650.516 under sprayed condition gave the highest yield which was significant ($P<0.05$) from all the clones tested under sprayed and unsprayed conditions. The result was in line with Habtamu *et al.* (2012), that described the application of fungicide reduced the progress of the disease as compared to unsprayed (controls), but Ridomil highly reduced the progress of the disease. The lowest yield was recorded from the unsprayed susceptible check (Table 7). On the other hand the highest yield advantage in using fungicide to control late blight was observed on the susceptible check which gave 62%. The standard check (Jalenie) also gave a 23.5% yield advantage over its unsprayed check. The potato clone with highest yield, CIP–392650.516 gave a 19.8% yield advantage over its unsprayed check (Table 7). Similarly, Habtamu *et al*. (2012) also found that the control treatments (no sprays) had the lowest tuber yield. Moreover, the highest potato tuber yield was obtained from resistant clones than the susceptible one due to their inherent resistant gene.

**Table 7. Main plot factor by sub-plot factor interaction responses across years, location and PR method used**

| **Potato clones** | **Average yield (t/ha)** | | **Yield advantage obtained in using fungicide (%)** |
|---|---|---|---|
| | **Sprayed** | **Unsprayed** | |
| CIP–392640.516 | 33.3**bc** | 28.5**de** | 16.8 |
| CIP–392650.516 | 38.4**a** | 32.1**bc** | 19.8 |
| CIP–386423.13 | 33.1**bc** | 30.4**cde** | 8.8 |
| Kp–90134.2 | 34.8**b** | 31.9**bcd** | 9.0 |
| Jalenie | 33.3**bc** | 27.0**e** | 23.5 |
| Susceptible check | 12.1**f** | 7.4**g** | 62.0 |
| t=1.96, α =0.05 | | | |

**Means in a column followed by the same letters are not significantly different at 5% probability level.*

As a participatory potato clones selection and evaluation against fungicide, Ridomil for their late blight reactions, farmers were given the chance of making their own preference test and have evaluated the potato clones through pair wise matrix ranking in respect to yield, disease reaction and taste. Based on their evaluation, two of the tested clones, CIP–392650.516 and CIP–392640.516 got a poor preference score on taste parameter which eliminated them from further test (Table 3). Whereas clone, CIP–386423.13 got second ranking on preference test after the standard check (Jalenie) which therefore qualified it for release and further dissemination for producers. Based on the ranking of clones by farmers using the analysis of the agronomic data and disease reaction data, the clone CIP–386423.13 was qualified for release in the year and the variety was named as 'Gudenie'by local language which means "We grew up". Similarly, interaction of fungicide sprays with varieties was significant ($p<0.05$). Fungicide sprayed treatments were significantly different from the unsprayed control on both elite clones and local variety. The use of durable resistance combined with scheduled applications of protective fungicides has been reported as useful for managing late blight (Simons, 1972), as well as other diseases (Van der Plank, 1963). Among the participatory approaches, FFS method helped the farmers to manage their fields better than the FRG and also got more advanced knowledge to manage other enterprises. Similarly, Hoque and Sultana (2012) stated that, FFS have been found as an effective approach towards increasing potato production in many countries like Indonesia, Nepal and Sri Lanka which need to be tested in Ethiopia. Moreover, for wider adoption of the FFS approach, it is also needed to demonstrate in the main potato growing areas among the farmers. In line with study, Karungi, *et al.* (2001) found that, generation and dissemination of cowpea integrated pest management technologies via participatory approaches highly effective for inducing changes among farmers. The authors further concluded that interactions with the farmers participating in FFS indicated that farmers were quite pleased with the approach citing the fact that they were now mandated to make decisions and choices about the crop management technologies. This view was also reflected by farmers in Ethiopia involved in this study.

## 4. CONCLUSION AND RECOMMENDATION

This study was conducted to evaluate participatory research approach to promote and disseminate integrated management of potato late blight disease in the central highlands of Ethiopia. In the participatory approach, the farmers were empowered with improved knowledge of potato production practices from planting to postharvest handling techniques. Adequate knowledge was transferred with the hard ware technology of potato production in FFS approach. The participant farmers' obtained access to detailed knowledge of improved ways of practicing each of the production processes through a series of sessions. The sessions helped them to have an impression with practical application fungicide application and use of late blight resistant potato clones. The other advantage of FFS to participant farmers is the spill-over effect to other enterprises. Therefore, complementation of the elite potato germplasm with limited amount of fungicide spray was one of the strategies to tackle the disease epidemics. But, when the disease pressure is very severe, intensive fungicide application is costly and the products may not always be available. Hence, the need to incorporate varietal resistance with fungicide spray is safe to the users and the environment.

The knowledge obtained from improved ways of potato production would also help to manipulate the production and management of other crops and enterprises in an improved ways. The farmers will keep on thinking differently no matter what the enterprise is because of their involvement in FFS approaches. The Researchers taking the concerns of the end-users into consideration and involving the latter in the evaluation helped to strengthen the trust between the partners and make the adoption of the technology very fast.

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