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PARTICIPATORY POTATO (SOLANUM TUBEROSUM L.) VARIETY DEVELOPMENT IN ETHIOPIA. A REVIEW

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A B S T R A C T

Participatory potato variety development includes the identification of the main components, participants and stakeholders, their roles, types of interactions and constraints identified in the system. Some research result indicates that, there is a less complex potato innovation system was observed at the plot site of Ethiopia and a more complex and dynamic system was observed in the case of Peru. Many Achievements were gained by participatory potato variety development in different part of Ethiopia. In southern Ethiopia, Umbulowach, Hawassa Zuria Wereda of Sidama Zone; Marachere variety was preferred by farmers for its excellent response in yield and other traits. In Tigray region of Atsbi woreda, from seven varieties three best performing varieties: Jalene, Gera, and Gudene were selected for their disease resistance and other quality traits. In North-western Ethiopia, With aid of CASCAPE project in South Achefer, Burie and Jabitehenan Districts, Belete variety was selected for its superior yield, disease and insect tolerance; In West shewa, at Jeldu, Dendi, Wolmera and Degem district, both Farmers Field School (FFS) and Farmers research Group (FRG) were established and a chances were given Farmers to select potato clones suitable to their conditions based on late blight disease resistance and yield. As a result, farmer's ranked as 1st, a potato clone CIP–392650.516 which is the highest yielder and late blight resistant among the tested clones); in Jimma area kersa (serbo), Seka Chekorsa and Dedo Districts, Farmers select Abalolarge 1 st, abateneh 2 nd and Gudane 3 rd as three high yielder variety and in Jimma and Illuababora zone area, variety "Guasa" was selected due to its earliness, high yield advantage and market demand.

Keywords: Potato plant breeding, Potato variety evaluation, Potato variety selection.

INTRODUCTION

The cultivation of potato was started in South America between 3 and 7 thousand years ago. Scientists believe that, it may grow wild in the region as long as 13,000 years ago (Nonnechke, 1989; Hawkes, 1990). It was introduced and distributed to Europe primarily to Spain in 1570 and the second to England in 1590. It spread gradually to America and Other countries (Nonnechke, 1989; Hawkes, 1990).

It is believed that potatoes entered Africa by colonizers, who consumed them as a vegetable rather than as a staple food for starch. The potato was introduced to Ethiopia in 1858 by the German botanist Schimper (Gebremedhin *et al.,* 2008). To Ethiopia; it is the earliest introduction and highest potential than any African Country. More than one million Ethiopian farmers are currently producing the potato crop where 80 % of them are found in Oromiya and Amhara Regional States (Abera & Fasil, 2005). In Ethiopia, the potato is grown in four major areas: the central, the eastern, the north-western and the southern. Together, they cover approximately 83% of the potato farmers (Hirpa *et al*., 2010; CSA, 2009). It has a high potential to supply cheap and quality food within a relatively short period. It is a well-balanced major plant food with a good ratio between proteins, calories, and substantial amounts of vitamins, especially vitamin C which promotes iron absorption, minerals, and trace elements like iron and zinc (FAO, 2008).

The first idea about participatory research (PR) in agriculture was initiated three decades ago (Rhoades & Booth, 1982; Chambers *et al.,* 1989). The idea and methods of participatory research are diagnosing to involving farmers in different steps of technology development and setting pathways of technologies scale

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out. Currently, it is widely accepted that the involvement of the consumers, beneficiaries or stakeholders related to a particularly valuable technology is very essential (Ortiz *et al.,* 2007).

Participatory plant breeding (PPB) is a dynamic and permanent collaboration that exploits the comparative advantages of plant breeding institutions, farmers and possibly other partners. It is also important that a truth participatory programmed is necessarily inclusive in relation to gender and has an empowering effect on the participants (Ceccarelli, 2012). Participatory Variety Selection (PVS) is a process by which the field testing of already finished or is going to be finished varieties usually done with the participation of the partners (Ceccarelli, 2012). In Participatory potato variety development include the identification of the main components, participants and stakeholders, their roles, types of interactions and constraints identified in the system. Taking into consideration the number of components and the intensity of interactions, a less complex potato innovation system was observed at the pilot site in Ethiopia and a more complex and dynamic system was observed in the case of Peru (Ortiz *et al*., 2007).

Many Achievements were gained participatory potato variety development in different part of Ethiopia. In southern Ethiopia, Umbulowach water shade located in Hawassa Zuria Wereda of Sidama Zone, Marachere preferred by farmers for its excellent ground cover, establishment, stem thickness, free from foliar and tuber disease, and uniform tuber size (Tefera, 2013). In Tigray region Atsbi woreda about seven varieties were tested on farmers' fields and three best performing varieties were Jalene, Gera, and Gudene were selected for their disease resistance, market quality/demand, and high yields; North-western Ethiopia With CASCAPE project in South Achefer, Burie and Jabitehenan Districts Belete variety was selected for its superior yield, disease and insect tolerance, maturity, cooking quality and adaptability (Hassen *et al.,* 2015) ;West shewa, at Jeldu, Dendi, Wolmera and Degem district, both Farmers Field School (FFS) and Farmers research Group (FRG) were established and a chance was given Farmers to select potato clones suitable to their conditions based on criteria such as disease resistance, taste preference, cook ability and yield. Accordingly, farmer's ranked potato clone CIP–392650.516 the highest yielder and late blight resistant among the tested clones. But it was ranked 5th in its taste preferences (Chindi *et al*., 2016); in Jimma areakersa (serbo), Seka Chekorsa and Dedo Districts, Farmers use different selection criteria to select their preferred varieties and accordingly Abalolarge 1st, abateneh 2nd and Gudane 3rd selected as the three high yielder variety (Hafiz, 2015) and Jimma and Illuababora variety "Guasa" was selected due to its earliness, high yield advantage and market demand (Beraka & Abrha , 2014). As a result, the objective of this paper is to review participatory potato variety development in Ethiopian case

Participatory potato (*Solanum tuberosum* L.) variety development in Ethiopia

Importance of potato: Potato can be baked, boiled, roasted, mashed and fried. Potato can be consumed alone or as a side dish with other foods. Most of the time potato consumed in the form of boiled and stew. As a result, CASCAPE has demonstrated home level potato processing to produce potato crisp, chips, porridge and Injera for farmers and youths (Hassen *et al.,* 2015). Moreover, it has the correct balance of protein calories and total calories. It is considered to be one of the cheapest sources of energy and the production of protein per unit land which is the highest stand among the four major food crops (rice, maize, wheat and potato).This shows potato can benefit large segments of the population(producers as well as the consumers) (CIP & FAO, 1995).However farmers are aware of the importance of the crop and looking for disease resistance /tolerance and high yielding varieties, and other technologies that improve the performance of the crop.

Production of potato in Ethiopia: In Ethiopia, the potato is grown in four major areas: the central, the eastern, the north-western and the southern. Together, they cover approximately 83% of the potato farmers (Hirpa et al., 2010; CSA, 2009).In the central area, potato production includes the highland areas surrounding the capital, i.e. Addis Abeba, within a 100–150 km radius (Figure 1). In this area, the major potato growing zones are West Shewa and North Shewa. About 10% of the potato farmers are located in this area (CSA, 2009). The average productivity of a potato crop ranges from 8 to 10 ton ha −1 which is higher than the productivity in the North Western and southern areas. The higher productivity might be due to the use of improved varieties and practices obtained from Holleta Agricultural Research Centre in the central area. In the central area, the potato is produced mainly in the belg (short rain season February to May) and mehr (long rain season from June to October) periods. Potato is also grown off-season under irrigation (October to January). Because of the

cool climate and access to improved varieties, farmers in this area also produce seed potatoes which are sold to other farmers in the vicinity or to NGOs and agricultural bureaus to be disseminated to distant farmers. In the central area, farmers grow about seven local varieties, eight improved varieties and six clones which is a genetic material and not officially released.

The eastern area of potato production mainly covers the eastern highlands of Ethiopia, especially the East Harerge zone (Figure 1). Only about 3 % of the total number of potato growers is situated in this area (CSA, 2009). But the area is identified specifically because the majority of the potato farmers in this area produce for the market and there is also an export to Djibouti and Somalia. Potato is mainly grown under irrigation in the dry season (December to April). This season is characterized by low disease pressure and relatively high prices (Mulatu *et al.,* 2005). Most farmers grow local potato varieties. However, some farmers in the vicinity of Haramaya University in the eastern area and farmers who are targeted by NGO seed programs have access to improved varieties (Mulatu *et al.,* 2005). Even though they use local varieties, the productivity of potato in this area is equivalent to the productivity in the central area which might be due to good farm management practices triggered by the farmers' and market orientation.

The north-western area of potato production is situated in the Amhara region (Figure 1). It is the major potato growing area in the country, counting about 40 % of the potato farmers (CSA, 2009). From these, South Gonder, North Gonder, East Gojam, West Gojam and Agew Awi are the major potato production zones. Farmers mainly grow local varieties. Productivity ranges from 7 to 8 ton ha −1. In this area, the largest volume of potato is produced in the belg season followed by irrigated potato produced off- season. Potato is also produced in the meher season. Some Data illustrate that, in the Awi district about 21 potato genotypes grown, of which 67 % were local varieties. Ninety percent of the farmers grew these local varieties.

The southern area of Ethiopia in which potato is grown is mainly located in the Southern Nations, and Peoples' Regional State (SNNPRs) and partly in the Oromiya region. The major potato producing zones in this area are Gurage, Gamo Goffa, Hadiya, Wolyta, Kambata, Siltie and Sidama in the SNNPRS and West Arsi zone in Oromiya. More than 30 % of the total number of potato farmers is located in this area (CSA, 2009). Potato tubers are produced under rain fed conditions and under irrigation. Productivity usually ranges from 7 to 8 ton ha −1, whereas in some places potato productivity is even below 7 ton ha^{-1}. About six varieties are grown, of which four are local and two are improved (Endale *et al*., 2008). In Ethiopia as a whole, more than 27 potato varieties with their full package were formally released for production for wider adaptation.

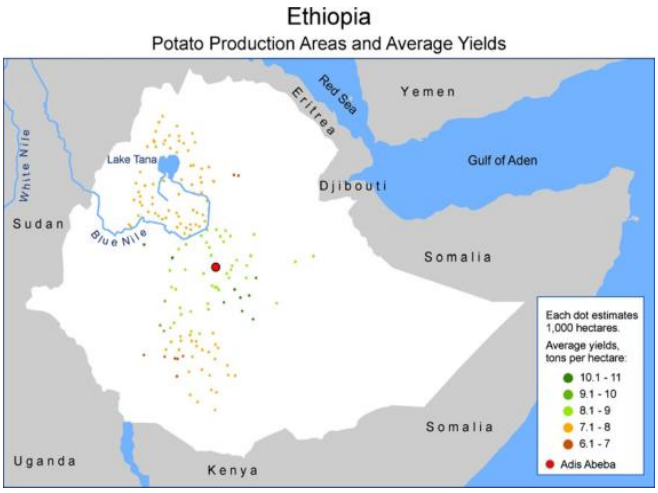

Figure 1. Potato production areas and average yields in Ethiopia.
Source: (Hirpa *et al.,* 2010).

Participatory variety development

Participatory Research (PR): The first ideas about participatory research (PR) in agriculture were initiated about three decades ago (Rhoades & Booth, 1982; Chambers *et al.,* 1989) and were initially taken up with skepticism by researchers and institutions. Those ideas and methods have evolved over the years, changing from participatory methods for diagnosing farmer problems to methods oriented to involving farmers in different steps of technology development including the final decisions about technologies to scale out. The types of technologies which PR deals with have also changed. Three decades ago, research institutions were more oriented to the development and delivery of input-based technologies (improved varieties, fertilizers, pesticides, seed, etc.).In recent years, institutions have shifted the focus to the development of technologies related to sustainable agriculture, which tend to be knowledge intensive. These are: - integrated pest management, integrated crop management, integrated resources management, etc. Currently, it is widely accepted that the involvement of the users, beneficiaries or stakeholders related to a particular valuable technology is very essential. However, principles and methods for

practising participatory research are still not facilitated and scaled out sufficiently among institutions involving in agricultural research and development sector to an extend that large numbers of farmers are reached and substantial contributions to poverty alleviation are made (Ortiz et al., 2007). Bechstedt (2005) indicates that "PR methods have rarely proven their usefulness beyond the micro level of on-farm trial sites". This is an interest focusing on the usefulness of PR for generating site-specific technologies, which, recognizably, would rarely generate technologies with a wider range of application. Therefore, as indicated by Menter *et al.* (2004), the scaling up and out PR methods would be important so that more institutions could develop technologies with higher possibilities of achieving wide-scale range impact. Hall *et al.* (2005) argue that, for the successful duplication of PR, an adequate policy and legal framework is needed. Those factors influence the duplication in complex innovation systems have not been studied sufficiently. In past, emphasis has been adhering on studying the factors that influence farmer involvement in PR and their opinions about the technologies being tested; but less focus has been adhering a on understanding the perceptions of other stakeholders about PR methods and the factors that facilitate or limit innovation and scaling up of such methods, taking into an account a wider view related to innovation systems (Lundvall *et al.,* 2002; Hall *et al.,* 2004; Gurung & Menter, 2004) and agricultural knowledge and information systems which highlight the importance of different stakeholders in the process (Engel, 1997).

Participatory plant breeding (PPB): PPB as a dynamic and permanent collaboration that exploits the comparative advantages both of plant breeding institutions (national or international) that have the institutional responsibility for plant breeding and of farmers and possibly other partners. It is also important that a truth participatory programmed is necessarily inclusive in relation to gender and has an empowering effect on the participants. A PPB program is similar to a CPB program in that it maintains the typical cyclic structure of a breeding program, but with three important organizational differences: Most of the program takes place in farmers' fields (decentralized), The decisions are taken jointly by the breeder and the farmers and partners and the program, being decentralized, can be replicated in several locations with different methodologies and types of germplasm (Ceccarelli, 2012).

In a "mature" PPB program, when farmer preferences are well identified, preliminary selection could be done on the station, using MAS when appropriate, but only for those traits of importance to farmers and not affected by G×E interactions, hence with high heritability. A PPB program can be replicated in various zones (agro-climatic areas or administrative provinces or regions within a country or countries). In each zone, the program can use different crops, different breeding materials within the same crop, and different experimental designs (Ceccarelli, 2012).

Participatory variety selection (PVS): Participatory Variety Selection (PVS) is a process by which the field testing of already finished or is going to be finished varieties, usually on a limited number, is done with the participation of the partners. Therefore PVS is always an integral part of PPB. Involvement of partners during the last stage of an otherwise non-participatory breeding program has one advantage and disadvantage. The advantage is when partners' opinion becomes part of the release process which follows the on-farm trials, only the variety(verities) that partners like will be proposed for release which increasing enormously the speed and the rate of adoption. The disadvantage is when partners' opinion is sought at the very last stage of the breeding program; there may be nothing left among the varieties tested in the on-farm trials that meet partner expectations. This disadvantage may induce the breeder to seek partner participation at an earlier stage of the breeding program, hence moving from PVS to PPB. PVS may also be used as a starting point, a sort of exploratory trial, to help partners assessing properly the amount of commitment in land and time that a fully-fledged PPB program requires (Ceccarelli, 2012).

Participatory potato variety development: Part of the study was oriented to characterize the participatory potato innovation systems, which included the identification of the main components, participants and stakeholders, their roles, types of interactions and constraints identified in the system. Participatory workshops were carried out at the pilot sites in each country and surveys to identify sources of information were conducted to complement the analysis. Although, the size and number of stakeholders involved in PR at the pilot sites were different in each country, results indicated that potato innovation systems vary across countries (Ortiz *et al.,* 2007).

The main groups of stakeholders identified in the system include farmer groups, organizations, government institutions, nongovernmental institutions, private

sector and media. Taking into consideration the number of components and the intensity of interactions, a less complex potato innovation system was observed at the pilot site in Ethiopia (Figure 2), and a more complex and dynamic system was observed in the case of Peru (Figure.3).potato innovation system is less complex and stable in Ethiopia, where government organizations still play a major role, compared to the other countries, where the government sector is limited and there is a major role on the part of NGO and the private sector. (Ortiz *et al.*, 2007). Stakeholders at all pilot sites pointed out the existence of limited interactions among the components of the system. For insistence, in the case studies from Peru, with larger number of components, only between 16% to 23% of the total potential interactions was reported (100% would be if all components interacted to each other) mostly involving farmers, which is an indicator of the lack of coordination and interaction particularly among support organizations both public (GO) and Non-governmental (Ortiz, *et al*., 2007). The main characteristic of the Ethiopian system is that it still includes a major government presence, in research, agricultural extension and input marketing, in contrast to the Bolivian and Peruvian systems where involvement governmental organizations in the innovation system are minimal. However, in the latter systems, local governments such as municipalities are starting to play an increasingly important role.

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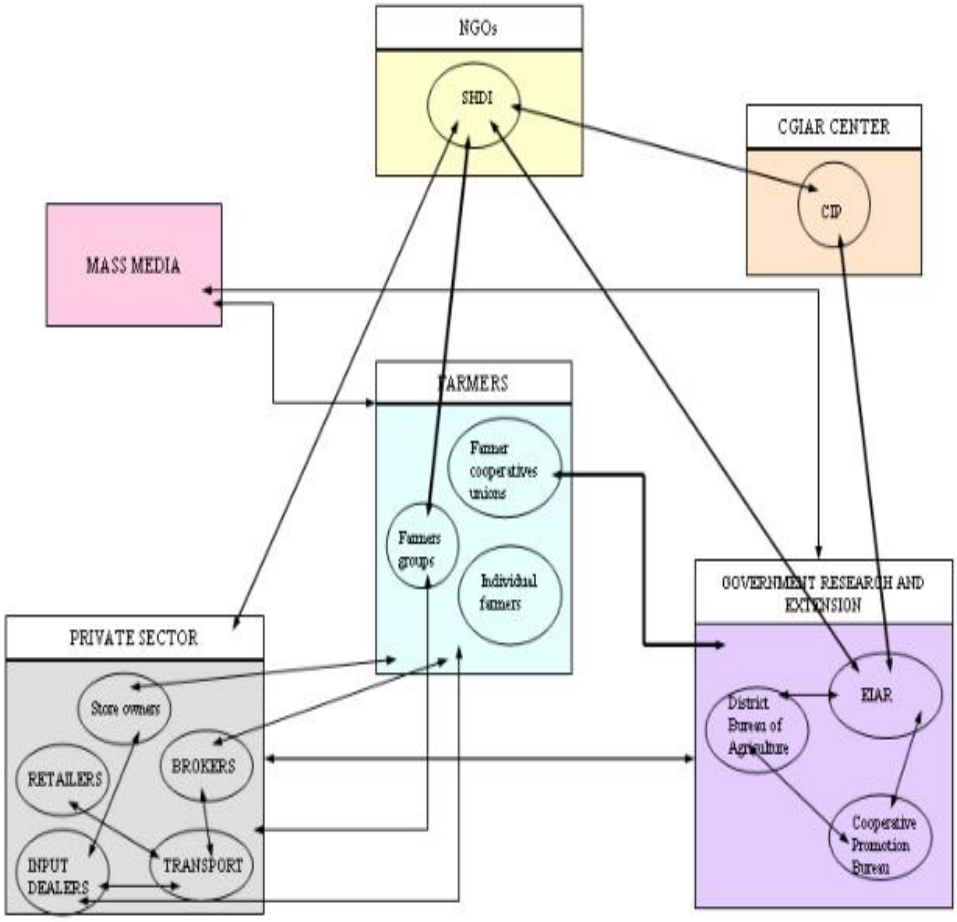

Figure 2. Components and interaction in the participatory Potato innovation system in Oromia, Ethiopia, 2004.
Note: The thickness of the arrows indicates the strength of the linkages and information exchange.
Source: (Ortiz *et al.,* 2007).

Achievements in participatory potato variety development in Ethiopia

Participatory potato variety selection in southern Ethiopia: Thirteen Farmers with development agent from the locality were selected and oriented on the importance of potato production, handling and utilization on Dancha and Marachere variety. The sprouted potato seed tubers (20 kg) of each variety (marachere and Dancha) were planted at each of selected farmer's field. Each farmer were considered as a replication. They were asked to set evaluation parameters those they were using to evaluate potato varieties. At vegetative stage, farmers' day in collaboration with Wereda agricultural office and Hawassa University was arranged. Performance data was planned, organized and analyzed by using the MSTAC software package. The variety Marachere over-weights by all variables of evaluation except for stem girth (cm) in which case the performance of both varieties is the same as indicated in Figure 4 below.

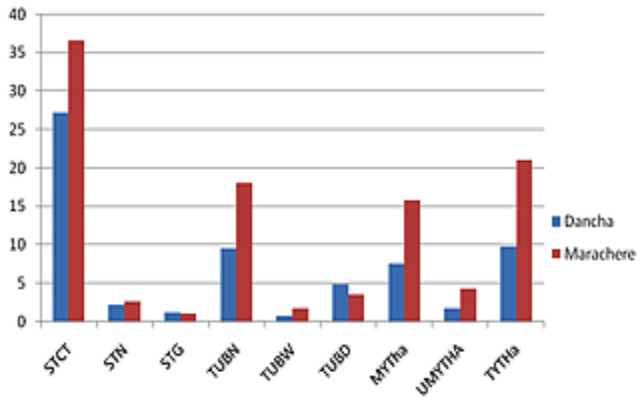

Figure 3 . Performance of improved potato varieties under Umbullowacho climatic Condition.
Source: (Tefera, 2013).

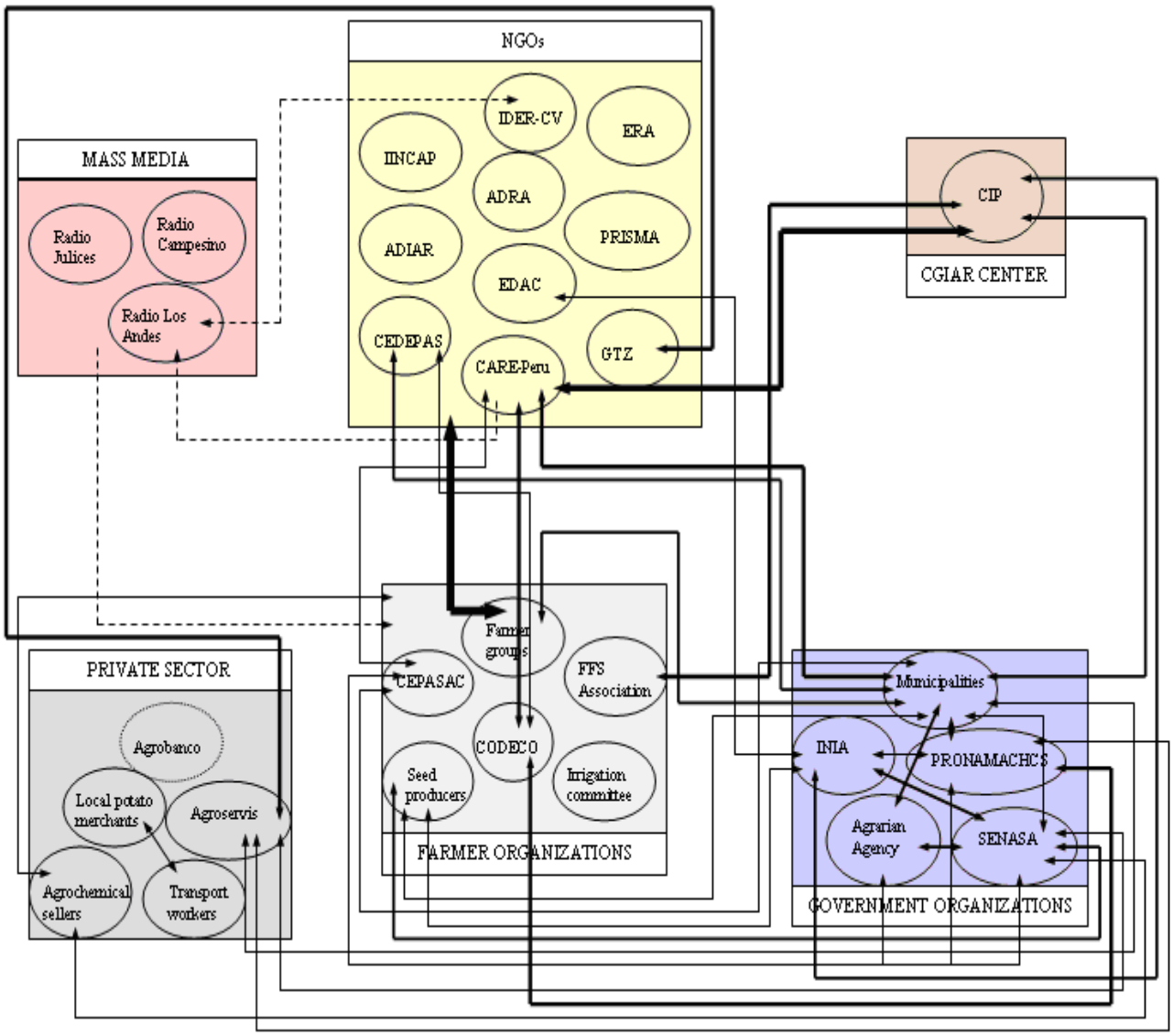

Figure 4. Components and interaction in the Potato innovation system in Cajamarca, Peru, 2004.
Note: The thickness of the arrows indicates the strength of the linkages and information exchange.

Source: (Ortiz *et al.,* 2007)

Even if the performance of the tested varieties is different among each other, the farmers selected both varieties by different merits. They preferred Marachere for its excellent ground cover, establishment, stem thickness, freedom from foliar and tuber disease, and uniform tuber size. Marachere, according to farmers view, has very minor drawbacks. It feels bitter and pungent taste up on swallowing while eaten boiled. They suggested the remedy for this as using the variety for "wat" preparation may reduce its unpleasant taste by the reaction of spices and hot paper. They also preferred the variety Dancha for its earliness, delicious taste when eating, low fire-wood consumption as it requires a short time for cooking, uniform tuber size. Among the preferred traits of Dancha, the farmers appreciated its earliness as they could cultivate this variety in a short rain before the onset of the recurrent drought experienced in the water shed (Tefera, 2013).

Participatory potato variety development in Tigray region of Ethiopia

Following stakeholder consultation: Participatory evaluation of potato varieties (PVS) was conducted in Atsbi woreda of Tigray. About seven nationally released varieties were tested on farmers' fields to select the best performing varieties for its yield, disease resistance, and market demand; Establishment of farmer groups. PVS

was conducted on farmers' fields in 2006 with the objective to select potato varieties that are adaptable and high yielding under farmers' field conditions in the area. Seven nationally released potato varieties: Tolcha, Digemegn, Zengena, Guassa, Gera, Jalene, and Gudene were evaluated under farmers' conditions. The three best performing varieties were Jalene, Gera, and Gudene (Fig. 5). They were selected for their disease resistance, market quality/demand, and high yields: Gudene (382 q/ha), Gera (388 q/ha), and Jalene 390 (q/ha), respectively. This yield is very high compared to the regional average of 80 q/ha. Hence, PVS results have revealed the possibility of increasing farmers 'income more than fourfold with the use of improved varieties compared to the local varieties, which are susceptible to disease and pest. (Gebrehiwot, 2013).

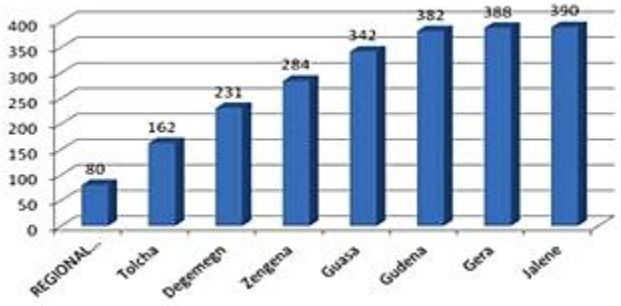

Figure 5. Average yield (q/ha) of potato PVS, 2006, under farmers' conditions in Atsbi.
Source: (Gebrehiwot, 2013)

Beside this Farmers Research (FRGs) were established in the Tabia, based on the experiences of EIAR and TARI. One FRG with 13 members was established. Training was given by staff from HARC and TARI on potato seed production and postharvest handling/management. The training was organized with practical exercise on farmers' fields. Farmer groups (FGs) who have participated in the PVS and have access to irrigation were grouped to work together to benefit from the seed production practices.

Participatory potato variety development North-western Ethiopia: With CASCAPE project trial adaptation was conducted for participatory selections of appropriate variety which is one of the most important management decisions made by the grower. Failure to select the most suitable variety or varieties may lead to loss of yield or market acceptability. Several improved potato varieties were released for different agro-ecologies in the country.

Among these CASCAPE has selected six improved varieties and evaluated in its intervention in applicable mid-altitude areas including South Achefer, Burie and Jabitehenan Districts of North-western Ethiopia (Table 1). Host and participant farmers in the three CASCAPE project districts have selected improved potato variety Belete for its superior yield, disease and insect tolerance, maturity, cooking quality and adaptability (Hassen *et al*., 2015).

Table 1. Tested improved potato varieties against the local check with their recommended altitude and rainfall.

Variety	Altitude(meter above sea level)	Rainfall(mm)
Belete	1600-2800	750-1000
Gudenie	1600-2800	750-1000
Jalene	1600-2800	750-1000
Guassa	1600-2800	750-1000
Gorebella	2000-3100	800-925
Zengena	750-1000	1000-1500

Source: (Hassen *et al.,* 2015).

Variety selection based on yield: CSACAPE demonstration result has indicated that 37 ton ha -1 has been produced from improved variety Belete as compared to 13 ton ha -1 from the local variety at South Achefer and Burie Districts (Table 2). The tuber yield advantage of Belete improved variety was found to be 185 % against the local check (with improved management practice) and 320 % as compared to the regional average productivity during the same production season 2010/2011 cropping season (Table 2).

Farmers preferences on the variety selection: Farmers were actively participated starting from the initiation of the innovation. They evaluated the innovation at different levels and cropping seasons (Figure 6). Finally, they preferred Belete potato variety based on its superior yield, disease tolerance, maturity and test quality over other varieties.

Table 2. Potato yield advantage (%) of varieties tested by CASCAPE.

Varieties	Productivity, ton ha -1	The advantage over the local variety (%)	The advantage over the regional average (%)
Guassa	34	161	286
Jalene	30	131	241
Belete	37	185	320
Gorebela	26	100	195
Zengena	23	77	161
Gudene	24	85	173
Local(variety with improved practice)	13	-	48

Regional average productivity 8.8 ton ha-1 (CSA, 2011) Source: (Hassen *et al.,* 2015).

Figure 6. Farmers' participation at different levels of potato technology evaluation for selection.

Source: (Hassen *et al.,* 2015).

Participatory Approaches of Farmer's field school (FFS) and Farmer's research Group (FRG) for variety selection resistant to potato late blight in West Shewa.

Established Farmers field school (FFS) and Farmer's research group (FRG): For a selection of resistant variety through IDM-LB potato, a trial was conducted 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 (Chindi *et al*., 2016).

Evaluation and selection of elite potato clones for palatability taste: In the conducted trail activities, farmers participated from site selection to harvesting and in the evaluation of elite potato clones for their late blight reaction under sprayed and unsprayed conditions. A chance was given Farmers to select potato clones suitable to their conditions based on criteria such as disease resistance, taste preference, cook-ability and yield. Accordingly, farmer's ranked potato clone CIP–392650.516 the highest yielder and late blight resistant among the tested clones. But it was ranked 5th in its taste preferences (Table 3). The clone CIP–386423.13 was ranked as 2 nd in both taste and yield but 4th in its late blight disease reaction (Chindi *et al.,* 2016).

Participatory evaluation of 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 a clone, Kp–10934.2 followed by a 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 check (local) which was said to be Susceptible (Chindi *et al.,* 2016).

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.

Legends: A score of 1 is for the best stand and 6 for the least. Numbers in racket are ranks based on mean evaluation of varieties. Source: (Chindi *et al.,* 2016).

Observed Tuber Yield during participatory evaluation: Yield evaluation was done by the analysis of variance and revealed that, there was a highly significant difference in yielding ability among the potato clones tested. 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 observed in ton ha-1during participatory variety evaluation

Potato clones	Yield ton per hectare
CIP–392650.516	35.2
Kp- 90134.2	33.3
CIP–386423.13	31.7
CIP–392640.516	30.9
Jalenie	30.1
Susceptible check	9.7

Source: (Chindi *et al.,* 2016).

Participatory variety selection and variability of potato (*Solanum tuberosum* L.)

Varieties in Jimma area: The trial experiment was conducted in kersa (serbo), Seka Chekorsa and Dedo Districts of Jimma Zone in Oromia Regional State on the

Farmer field. Different evaluation and selective system were employed and showed that vary with farmers preferences. From different evaluation system, Farmers employed nine different selection criteria to select their preferred varieties including Cooking time, Free from disease, Tuber uniformity, Tuber yield, Marketable, Unmarketable and taste (Figure 7). From the conducted experiment, farmers select variety based on yield Abalolarge and Abateneh, where higher yielder genotypes while gabbisa the least preferable. Tuber uniformity: Abateneh, Marketable: Abateneh, Unmarketable Gabbisa and Ayito, date of Maturity: balolarge and zengena, number of steam: Gabissa and ayito and Taste: Jallane and Abateneh were selected by farmers as the most preferred attributes showed in appendix table .The three characteristics, high yield, disease tolerance and Marketable are the most important trait in. in potato (Hafiz, 2015).

Figure 7. Participatotory potato variety evaluation and selection at Seka, Dedo and Serbo. Source: (Hafiz, 2015).

Yield and tuber quality play an important part in the successful production and marketing of potato. Traditionally, high yielding ability alone was the most important factor to the producer. In the three sites Serbo, Seka and Dedo Varieties which show higher yield and score high percent response rate in participatory variety selection were ranked as 1st, 2nd and up to10th. Accordingly Abalolarge 1st, abateneh 2nd and Gudane 3rd selected as the three high yielder variety while other is varieties were low yielder and selected less by the farmers in the study area (Hafiz, 2015) (Table 5). In line with this experiment, Nkongolo *et al.* (2008) reported that farmer select 20 accessions based on its yield and yield components in two experimental stations. Based on the participatory result observed, they can use interesting variety because most the time's many farmers believed that improved cultivars would give no benefit unless provided with additional inputs, and the same variety was multiplied by selected farmers or purchase the same variety from research centre (Yihenew *et al*., 2014). There are differences in number and size of marketable. The result from participatory variety selection indicated that Gudane, Abalolarge and Abateneh ranked and selected. This is because this variet have a large number and big size potato tubers when compared to other varieties such as Gabbisa, Jallane and Ayito which has low yield and small size tuber variety. In seka the highest score number of the marketable tuber is for Abateneh, Gudane and Abalolargethe same results was observed in Dedo districts. Therefore, Farmers' characterization of variety with yield and yield component were useful in selecting the best performed variety that has been acceptable at a wide range of economic importance (Table 5).

This multidisciplinary approach ensured the selection of accessions with acceptable of the materials released. Even if the performance of the tested varieties is different among each other, the farmers selected the three varieties by different merits. They preferred Abateneh, Abalolarge and Gudane for its excellent yield, marketable preferences and disease resistance, tuber uniformity, early maturity, cooking time, number of steam and date of flowering in overall location (Hafiz, 2015).

Table 5 . The overall selection of potato variety in % and its rank by participatory.

Variety name	Overall %	Rank
Ayito	28.30	7
Jallane	28.72	6
Abalolarge	51.23	2
Gudane	41.24	3

Ballate	25.97	8
Abateneh	54.61	1
Gabissa	18.99	10
Gorobella	33.64	5
Shenkolla	23.19	9
Zengena	34.11	4

Source: (Hafiz, 2015)

Participatory Variety Adaptation and Adoption in Jimma and Illuababora zone: From the conducted experiment in Jimma and Illuababora zone Members have better adapted and adopted the introduced potato varieties than non-members. Thus, the dramatic shift to production of variety "Guasa" was observed where 95 % of the members opted to use it while the remaining (4.7 %) cultivated the other improved variety "Jalene" but none of them opted to use the local varieties. The first variety "Guasa" was selected due to its earliness (82.7 %); high yield advantage (78 %) and market demand (41.3 %). Despite great enthusiasm to try new things, non-members were constrained with resource limitations to take risks and carry out experiments with their meagre resources. Hence, they were opted to use traditional experiences. Thus, the participatory variety selection fostered the attraction of local knowledge to meet farmers' dynamic user demands and to choose their best bet variety, which they believe have the capacity to develop commercially accepted variety (Beraka & Abrha, 2014). This trial result was similar with the trial result report of IFPRI (2010) which indicated that increasing quality and use of improved seeds through participatory farmer dramatically increased Ethiopia's annual crop production.

CONCLUSION AND RECOMMENDATIONS

In Ethiopia, potato is grown in four major areas: the central, the eastern, the north western and the southern. Together, they cover approximately 83 % of the potato farmers. The first ideas about participatory research (PR) in agriculture were initiated about three decades ago. Participatory methods for diagnosing farmer problems is a method oriented to involving farmers in different steps of technology development up to final decisions of technologies to scale out. PPB is a collaboration that exploits the comparative advantages both of plant breeding institutions, farmers and possibly other partners. Participatory Variety Selection is a process by which the field testing of already finished or is going to be finished varieties. Through participatory potato variety development in consideration, a number of components and the intensity of interactions; a less complex potato innovation system was observed in the site of Ethiopia and a more complex and dynamic system was observed in the case of Peru. Many achievements were gained through participatory in different part of Ethiopian .These are : in Umbulowach water shade located in Hawassa Zuria Wereda of Sidama Zone: Dancha was selected by farmers; in Atsbi woreda of Tigray, three best performing varieties: Jalene, Gera, and Gudene were selected for their disease resistance, market quality/demand; in North-western Ethiopia, South Achefer and Burie Districts, farmers preferred Belete potato variety based on its superior yield, disease tolerance, maturity and test quality over other varieties; in West shewa, farmer's ranked as 1st potato clone CIP–392650.516 the highest yielder and late blight resistant among the tested clone; in Jimma area, Abateneh, Abalolarge and Gudane were preferred and in Jimma and Illuababora zone, "Guasa" was selected due to its earliness, high yield advantage and market demand. In the future, Plant breeding program should through farmers participatory and other sectors for sustainability and acceptability.

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Acronyms used

FAO	Food and agricultural organizations
SNNPR	South Nationality Nations Peoples Republic
PPB	Participatory Plant breeding
PVS	participatory variety Selection
CASCAPE	Capacity building for scaling up of evidence-based best practices in Agricultural production in Ethiopia
FRG	Farmers Research Group
FFS	Farmer Field School
q/ha	quintal per hectare
NGOs	Non-Governmental Organizations
ton ha -1	ton per hectare
CSA	Central Statistics authority
AUDPC	Area under desease progressive curve