



DIAGNOSTIC SURVEY ON POTATO PRODUCTION PRACTICES IN ERITREA

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ABSTRACT

A baseline survey was conducted in Zoba Maekel and Zoba Debub, Eritrea, to determine existing potato production practices and identify areas of intervention for optimization of its productivity. The study will contribute to improved food security and livelihood of poor farmers in the country. Within each Zoba, the Sub-zoba/village (strata) was purposely selected based on their history and coverage in potato growing, while farms (sites) were randomly selected for the study. Farmer respondents were interviewed (by enumerators) based on a comprehensive set of questions on their potato growing practices. Useful information, on house hold characteristics, farm land and crop management practices, seed source, rotation, irrigation and fertilization methods, weed, pest and disease management, and yield were collected. In addition, to structured questionnaires focus group discussion with groups of selected farmers was conducted. Although, the degree and level might vary from growers to growers and Zoba to Zoba, it was noted from the survey that growers face major challenges in obtaining farm inputs especially quality tuber seeds, fertilizers and pesticides. Moreover, pest prevalence particularly, Cut Worm infestation (87%) and Late Blight infection (97%) were observed throughout the visited villages posing major problem to growers. It is, therefore, recommended to secure availability of major farm inputs and provide frequent extension services to improve farmer's knowledge and understanding. Especially, consideration should be given to the establishment of sustainable and standard seed supply scheme at all levels.

Keyword: potato, Eritrea, farming systems.

INTRODUCTION

Agriculture is the mainstay for more than 70% of Eritrea's population and one of the most important economic sectors of the country. The main food crops grown include: wheat, barley, maize, sorghum and pearl millet, and many forage and horticultural crops. One of the common vegetable crops grown is potato. It grows widely in the highland part of the country, mainly by small scale farmers with low input low output practice with an estimated area of 24, 000 ha and production of 285, 339 tones per year. It is grown both for home consumption as well as for cash. Because of this double purpose, the potato crop plays an important role in the rural livelihood system of many countries (Gildemacher, 2012).

In Eritrea, potato production is concentrated mainly in the highlands of the country, more particularly in Zoba Maekel and Zoba Debub. It is a key component in the livelihood systems of small-scale farmers in these regions. The crop is grown both under rain fed and irrigated condition often in small parcels of lands with limited resources. The production and thus supply of potato in the market fluctuates from time to time. As a result, the price soars from day to day. A careful understanding of the context is, therefore, important to identify the core problem and hence find ways how to enhance productivity and stabilize the situation. It has been demonstrated that, quantitative and qualitative surveys help to understand the potato farming system (McPharlin and Taylor, 2005). Furthermore, for improved productivity of potato, it is essential that farming systems are understood in order to identify and implement necessary intervention.

Baseline survey on potato crop has been conducted in many countries such as Kenya, Ethiopia and Uganda (Gildemacher, 2012); Kenya (Muthoni and Nyamongo, 2009; Muthoni, *et al.*, 2013); India (Kadian *et al.*, 2010); Ecuador (Barrera and Norton, 1999), Indonesia (Dawson, *et al.*, 2005), Argentina (Caldiz, 2000). According to Gildemacher, *et al.*, (2009), for instance, for effective targeting of research and development efforts, a more detailed country or region specific analysis of the potato system and its potential opportunities and possible constraints is required. The survey not only helps to identify relevant areas of intervention, but also helps to identify weaknesses within the system that need to be revised immediately. However, no survey study was conducted in Eritrea to study the current potato production system practices.

The current study is, thus, designed to gather and document potato cultivation system in Eritrea with particular emphasis on land management systems prevailing in the area, household and farm characteristics, cropping pattern, cultural practices, pests and their control, and yield. It was envisaged that the information gathered would assist in the identification of the main areas of intervention for planning future potato production activities in order to improve productivity and hence livelihood of growers.

MATERIALS AND METHODS

The study was conducted in the two major potato producing Zobas (regions) of Eritrea (Zoba Maekel, and Zoba Debub). Zoba Maekel, the smallest of the six Zobas of Eritrea, lies between 15°10' - 15°35'N latitude and



38°41'- 39°30'E longitude, and an altitude of between 1276 to 2625m. Annual rainfall records, from 1997 to 2007 show a maximum of 574 mm in 2001 and a minimum of 297 mm in 2002 (Abraham, *et al.*, 2009). The mean maximum and mean minimum annual temperatures are 25.5°C and 4.3°C, respectively. The potential arable land of the Zoba is estimated at 46, 966 ha with a predominating soil type of *Luvisol*, *Cambisol* and *Lithosol-Cambosol* (FAO, 1988).

Zoba Debub is located along a portion of the national border with Ethiopia 14°25'-15°10' N latitude and 38°15'-39°-45' E longitude. It is the largest region in the country by population. The mean annual rainfall ranges between 300 and 700 mm with mean annual temperatures exceeding 22°C. The soil type of this region is dominated by *Cambisol*, *Lithosol-Cambosol* and *Vertic-cambisol* (FAO, 1988). Agriculture is an important economic activity in the two Zobas where for the majority of the population it remained to be a source of livelihood, employment and food security.

The survey was carried out by interviewing representative growers using a semi-structured questionnaire, discussing with focus group farmers using the participatory rural appraisal (PRA) tools and conducting physical observation. The sampling design was developed in consultation with experts from the MoA in each Zoba to identify areas according to their potato

cultivation coverage and experience. Accordingly, more than 20 villages from each Zoba were identified (Figure-1). This was then followed by stratified sampling. It was noted from the informal observation that farmers from the same village use more or less the same farming practices. Thus, it was necessary to increase the number of villages than the number of farmers per village. Accordingly, 138 farmers from over 40 villages were interviewed.

Data was collected on farm to assess the actual farming practices, history, area under cultivation, crop vigour and health. To manage the data collected efficiently, data entry forms were developed using EPIDATA data entry and management software (Epi Data 3.1). Data was then exported to the Statistical Product and Service Solutions (SPSS) software package for major statistical analysis. For generating geo-referencing coordinates of visited locations, a global positioning system (GPS-Garmin Oregon 550) was used.

Qualitative and quantitative raw data collected from the diagnostic survey were analysed to draw and generate useful information for documentation and to serve as useful reference for scientific community and policy makers. Quantitative data from the survey were subjected to a statistical analysis using SPSS for computational analysis after which results were expressed in the form of means (averages), and percentages.

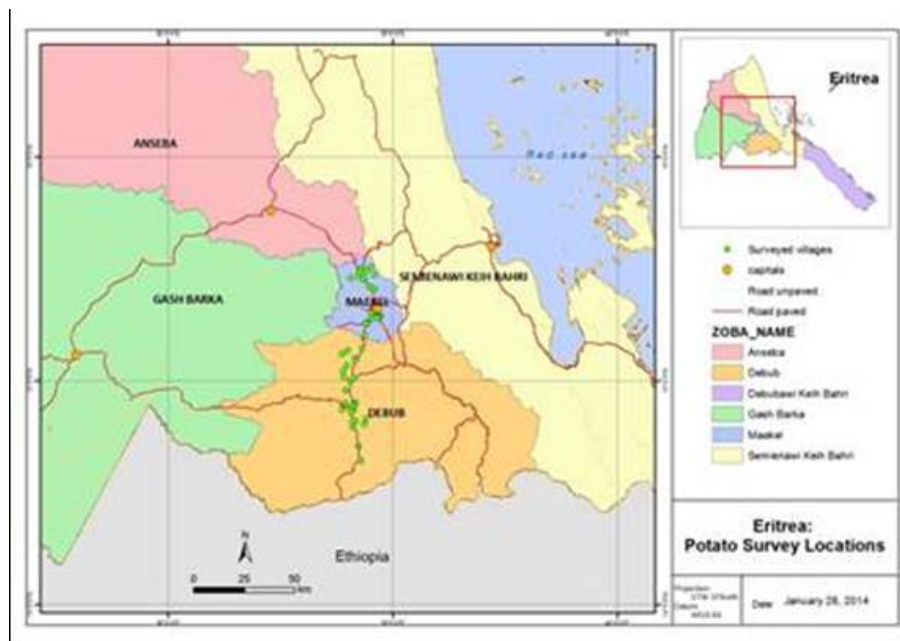


Figure-1. Location map of the visited villages in Zobas Maekel and Debub.

RESULT AND DISCUSSIONS

Basic household information

The study yielded information on farmers' family size, gender, age, educational level and experience on potato production. The respondent growers were predominantly male (93.5%), ranging between 16 and 85

years of age with an average age of 51 years. Majority of the growers fell in the 41 to 55 years of age. About 52.2% of the growers were either illiterate or had elementary school education only. On the other hand the very few young and middle aged growers interviewed were either high school or college graduates. The average family size at house hold level varies between 5.4 to 7.8. During the



focus group discussion, farmers from the two Zobas mentioned that potato cultivation in the area dated back to the early 20th century. Potato growing experience ranged

from 2 to 66 years with majority of them growing it for more than 20 years (Table-1).

Table-1. Basic household and village characteristics.

Zoba	Subzoba	Altitude (m.a.s.l)	No Farmers interviewed	Average family size	Average growing experience (yrs)
Maekel	Asmara	1995-2454	7	5.4	18
	Galanefhi	1627-2425	17	6.9	23
	Serejeka	1305-2606	30	6.9	36
Debub	Mendefera	1596-2529	37	6.7	27
	Debarwa	930-2567	23	7.4	27
	Emnihayli	1340-2048	13	6.3	21
	AdiQuala	1352 -2148	11	7.8	18
Total	7		138		

Cropping systems

Land management and use

The land tenure and acquisition system of all the surveyed areas included *Risty* (individual), *Diesa* (communal), rented and/or shared (between contractor and owner). In majority of the country's highlands, the *Diesa* system is predominantly practiced. The main characteristics of the system is that the land is basically owned by the community, thus every permanent resident is entitled to share it equally through a periodic redistribution (usually 7 years) to all community members (Negassi, *et al.* 2002). In other words farmers only have the right to cultivate the land but not own it. But still farmers can

obtain additional farmland through a variety of tenancy arrangements (Tewolde and Ghebreyohannes, 2003). The *Diesa* system is criticized for not encouraging growers to put long-term investment on the land as they know it will be redistributed to others after a certain interval, although it provides equitable access to all members (NFIS, 2005; Negassi, *et al.*, 2002). This idea was reaffirmed by most of the growers during the PRA discussion in the two Zobas. It was noted from the study that majority of the respondents use either *Diesa* and/or rent system. The average might vary from one Zoba to another however majority fall into the rented system in Zoba Maekel while *Diesa* followed by rent systems dominate in Zoba Debub (Table-2).

Table-2. Land management practice of the visited villages in Zoba Maekel and Zoba Debub.

Zoba	Land acquisition systems				Total
	Risty	Diesa	Rented	Other*	
Zoba Maekel	27.8%	27.8%	40.7%	3.7%	100.0%
Zoba Debub	3.6%	47.6%	40.5%	8.3%	100.0%

*Other means shared with the owners

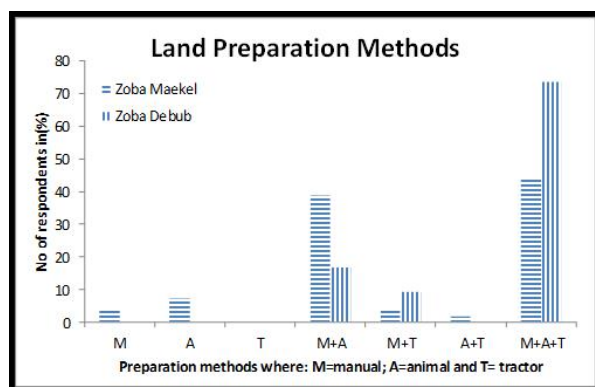
Results from the study indicated that the area in which potato is cultivated is dominated by flat area and clay soil type (Table-3). It's clearly shown from the findings that areas in Zoba Maekel are dominated by sloppy and mountainous topography, especially in sub Zoba Serejeka. This is probably the main reason why few

commercial farms exist around the capital Asmara (NFIS, 2005). Whereas the topographic nature of Zoba Debub is characterized by having more plateau and flat area ideal for large scale commercial farming. The presence of relatively more semi-commercial growers in Zoba Debub is partially attributed to this.

**Table-3.** Topographic characteristics and soil types of the study areas.

Zoba	Sub Zoba	Topography		Soil type				
		Flat (0-2%)	Gentle slope (2-8%)	Clay	Sandy loam	Loam	Silt clay	Sandy clay
Maekel	Asmara	85.7%	14.3%	57.1%	28.6%	14.3%	-	-
	Galaneffi	70.6%	29.4%	82.4%	-	11.8%	5.9%	-
	Serejeka	43.3%	56.7%	13.3%	33.3%	26.7%	26.7%	-
Debub	Mendefera	94.6%	5.4%	73.0%	-	5.4%	21.6%	-
	Debarwa	91.3%	8.7%	43.5%	13.0%	8.7%	30.4%	4.3%
	Emnihayli	92.3%	7.7%	61.5%	-	15.4%	23.1%	-
	AdiQuala	90.9%	9.1%	81.8%	-	-	18.2%	-
	Percentage	79.0%	21.0%	55.1%	10.9%	12.3%	21.0%	0.7%

Growers in the study area use different methods of land preparation. Farmers in Zoba Maekel prepared their land manually and/or using animal traction. This was in agreement with an earlier study by NFIS (2005) where it was mentioned that land preparation in Zoba Maekel is largely carried out with traditional oxen-drawn ploughing method. Growers from Zoba Debub, on the other hand, use manual labour and animals (16.7%); manual and tractor (9.7%) with the majority using combination of all methods (73%) to prepare the land. The Figure is slightly different in case of farmers from Zoba Maekel where only 44.4% use a combination of all methods (Figure-2).

**Figure-2.** Land preparation methods for potato cultivation in the two Zobas.

The average farm size of the growers during the on-season (rain fed) ranges from 0.2 to 13.5 ha (including rented), and from 0.2 to 20 ha during off-season (irrigation system). Accordingly, areas cultivated with potato differ substantially between individual farms. It is worth mentioning; that more than 60% of the farmers own land that is less than 2 ha in size. Earlier, it was reported by Tewelde and Ghebreyohanes, (2003) that average land holding is at a maximum of 1 ha. Furthermore, findings of the current study indicated that about 62% of the growers allocate part of their land for potato growth during the rainy season and about 93% during the off-season. This

result clearly indicates that potato is a priority crop for most of the growers both during on and off-season of the year. Tamm, *et al.*, (2004) also reported that European potato growers (farmers) use 5 to 15% of their arable land for potato production and in exceptional circumstances reaching up to 30 to 47%. The current result further showed that the average land allocated for potato production ranges from 0.05 to 5 ha and 0.1 to 10 ha during on and off-seasons, respectively. It was, however, noted that more than 65% and 67% of the growers during the on and off-seasons, respectively allocate less than 1 ha of their land for potato. This confirms the previous findings by several authors that potato production in Eritrea is practiced by small scale farmers. More or less the same farming pattern was reported in Kenya (Muthoni, *et al.*, 2013). When the distribution and land allocation for potato production in the two Zobas is compared, relatively growers in Zoba Debub own larger areas both for rain fed and irrigated. This can be ascribed to the fact that in Zoba Debub the topography is suitable as well as majority of the growers are semi-commercial thus have better access to resources and are able to rent larger areas.

Planting

The on-season (rainfed) farming is practiced during the summer season (June-September) while the off-season is mainly during autumn (September- December) and spring (March-June) periods of the year. The range and period of the on and off-season might vary from location to location. To this effect, growers in Zoba Maekel start their on-season planting time early towards the end of June. Whereas growers in Zoba Debub start planting late between mid of July to August (results obtained from focus group discussion). This variation can be associated with the types of variety used and farming practices, on top of others. In Zoba Maekel majority use the landrace varieties (especially during on-season) which take longer time to mature. As a result, they should be planted early to make use of the rainfall distribution effectively.

Another interesting point raised by the growers during the group discussion is that farmers opt to plant



local varieties instead of improved/imported varieties because local varieties have shorter dormancy. Thus, the local varieties become ready for planting before the imported ones, although they require more water and time to reach maturity. They are aware that the crop should not be subjected to water shortage, especially after flowering (critical period). Thus, the growers prefer to grow the old varieties during the long rainy season (summer) period. Similar results were reported by Kadian, *et al.*, (2010) for Indian growers.

Most of the farmers stated that they used no specialized quality grading system prior to storage. Some farmers reported that they apply Sevien and locally available ash and sand to protect the harvest from insect attack. It was also observed from the survey that most of them do not have proper storage facilities; they instead used a separate room of different size that could provide optimum aeration and humidity usually cooled by ambient air. This system is widely practiced across all Eastern African countries leading to low yields (CIP, 2011).

Almost all (90%) of the surveyed growers replied that they use whole seed planting method with few (10%) practicing both whole and cut methods. The growers said cutting is not common because they think the seed tuber will get rotten immediately if cut into pieces. As a result they plant it whole even if the tuber is big in size and are in short supply of seeds. Yet, others mentioned that they did not have any idea on the practice of seed cutting.

Seeding rate of potato ranges between 0.4 to 3 tons/ha. A wide difference between the two Zobas was evident where growers in Zoba Maekel use about 1.2 tons/ha while growers in Zoba Dehub use almost 2 tons/ha. Seeding rate of 1.5 tons/ha was reported for Indonesian farmers by Dawson (2012). The lower seeding rate in Zoba Maekel can be ascribed to the fact that most farmers in this Zoba use the local landrace varieties such as Tsaeda Embaba, Keyih Embaba and Shashemanie. These genotypes are known for having small sized tubers as compared to the recently imported ones, thus making the total weight of seeds relatively lower. According to Dawson, (2012) small seed tubers are favoured in some parts of Indonesia due to their lower cost as seed potatoes are usually sold by weight.

Cultural practices

Most of the growers responded that they grow potato in pure stand. Some of them mentioned that they included maize, especially along the border of the seed

bed, as a means of windbreak. Potato intercropping is, however, a common farming practice in some other parts of the world. In Ecuador, for instance, most farmers plant a combination of other crops such as wheat, barley, corn, faba beans, peas, and forage with potatoes (Barrera and Norton, 1999). It is grown in multiple cropping systems in rotation with other vegetables or cereal crops in many parts of Asia and Pacific (Pandey, 2009). In the current survey, more than 98% of the interviewed farmers practice crop rotation with different crop types mainly cereals, legumes and other vegetable crops. The most remarkable point is that, all are fully aware of crop rotation and its ability to improve soil fertility and suppress soil borne diseases and buildup of insects. According to Tamm, *et al.* (2004), crop rotation is a crucial element of the soil fertility management strategy. Unfortunately, for some of the growers, especially in Zoba Maekel, Sub Zoba Serejeka, crop rotation is not commonly practiced, owing to the relatively inadequate availability of land. It was reported by Tamm, *et al.* (2004) that even for growers in developed countries like Europe, the crop rotation patterns are not typical for specific growers and there is no obvious relationship between soil type and crop rotation, indicating that farmers adapt the crop rotation pattern to specific needs and less to the environment.

Almost all the growers (91%) in Zoba Maekel and Zoba Dehub practice the furrow irrigation system with limited drip irrigation and overhead rainfall. The respondents mentioned that they are only accustomed to furrow irrigation system because it requires no special skill and resources. This agrees with the previous report by Tewolde and Ghebreyohannes, (2003); Negassi, *et al.*, (2002). This method is, however, known for its excessive water use and transport water loss as compared to the other methods. All the growers own (or hire) water-pump generators to collect and distribute irrigation water from wells into the furrow (Figure-3). More than 84% of the respondents collect water from wells and only few from dams and streams (Table-4). Previously it was reported by Negassi, *et al.*, (2002) that since there are no perennial rivers, streams or lakes, for most growers in Eritrea, wells and dams are the main sources for irrigation and domestic water use. Although, water availability is described as moderate by about 43% of the respondents, it remains a common bottleneck in Zoba Maekel, especially in sub Zoba Serejeka where more than 50% of the respondents indicated that they have acute shortage of water.

**Table-4.** Water sources and irrigation methods of the sub Zobas visited.

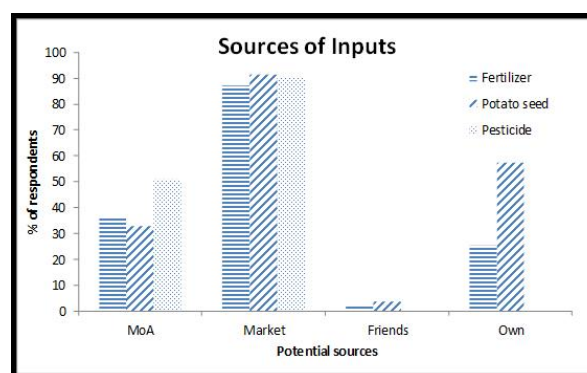
Zoba	Sub Zoba	Water source				Irrigation system		
		Well	Stream	Dam	Other*	Drip	Furrow	Other*
Maekel	Asmara	100.0%	-	-	-	-	100.0%	-
	Galaneffi	100.0%	-	-	-	-	100.0%	-
	Serejeka	40.0%	16.7%	10.0%	33.3%	-	66.7%	33.3%
Debub	Mendefera	97.3%	-	2.7%	-	-	100.0%	-
	Debarwa	100.0%	-	-	-	-	100.0%	-
	Emnihayli	84.6%	7.7%	-	7.7%	7.7%	84.6%	7.7%
	AdiQuala	100.0%	-	-	-	-	100.0%	-
	Percentage	84.8%	4.3%	2.9%	8.0%	0.7%	91.3%	8.0%

*Rain fall

**Figure-3.** Furrow irrigation system (left) and a well main source of irrigation water (right).

All the growers interviewed agree that they should apply either organic and/or inorganic fertilizer to boost-up productivity. According to Wolf and Kipps (2004), compared to most other important vegetable crops, the potato crop removes more total nutrients and a high ratio of potash from the soil. Farmers are generally aware of the importance of fertilizers and almost all the growers apply fertilizers to their fields one way or another. The most commonly used fertilizer types are Di-ammonium Phosphate (DAP), urea and farmyard manure (FYM). In Eritrea, most growers use a combination of fertilizers, although the degree and level varies from one grower to another and from one Zoba to another. In Kenya, farmers use considerable amounts of inorganic fertilizer (DAP) and FYM, while in Ethiopia, only inorganic are widely used in potato production (Gildemacher, 2012). In general, many of the growers in the current study expressed their dissatisfaction that they have limited access to fertilizers. Consequently, over 80% of the respondents complained that there is insufficient fertilizer supply. Thus, they are forced to purchase from the market at a higher price. Although the amount and its availability is highly limited, sometimes the Ministry of Agriculture (MoA) provides them with fertilizer at a reasonable price. Very few borrow

from their friends while others use their own FYM (Figure-4).

**Figure-4.** Potential source of major potato cultivation inputs.

Motives to use FYM included economic considerations (availability on farm) as well as agronomic reasons as FYM was generally considered as fertility input (Tamm, *et al.*, 2004). In a similar manner about 52% of the growers mentioned that they use more fertilizer during



the off-season than in the on-season period. Application practices vary depending on rainfall, soil type, crop rotation, and type of farming system (Wolf and Kipps, (2004).

As a routine practice of potato cultivation, growers in Eritrea use different types of insecticides and fungicides. The types used might vary depending on factors such as price, availability, accessibility, knowledge, season and location of the site. Nevertheless all the growers admit that they use at least one type. The types of insecticides used include but are not limited to: *Malathion*, *Focus*, *Dursban*, *Roger*, *Cypermethrine* and *Ectodip*. While *Ridomil*, *Mancozeb*, *Zulfo*, *Anadoul*, and *Dithane* are used as fungicides. Majority of the growers (97.1%) use *Malathion* followed by *Focus* (58.7%) to control insect infestation whereas *Zulfo* followed by *Mancozeb* are among the widely used fungicides. On the other hand *Cypermethrine* (7.2%) preceded by *Dursban* (18.1%) insecticides and *Anadoul* (4.3%) preceded by *Dithane* (7.2%) fungicides are the least used chemicals. More than half of the respondents replied that they apply more fungicides during the rainy season because it is associated with high disease prevalence, especially fungal diseases.

There is an acute shortage of pesticide availability to most of the growers. Figure-4 shows that majority of the growers obtain their pesticide inputs from the market with limited amount available from the MoA. To make matters worse, the pesticides from the market are not only expensive but are also not properly labeled and the expiry dates are not clear. This situation exposes the applicants to serious health hazards, causes environmental pollution and eventually increases cost of production.

Pest prevalence and their control

Pests are the main yield reducing factors in all cultivated crops. Likewise potato is a host crop to a number of insect pests and pathogens impairing productivity or usefulness of the crop. All the interviewed farmers unanimously reported that insects and diseases are a major pest on potato production. A number of existing and newly introduced insect pests and pathogens attack the potato crop frequently. According to Hooker (1981), potato is a high-value crop with complex production, storage and utilization problems that require appropriate prevention practices. All the growers from the current survey mentioned that diseases are common during the rainy season while insect pests are common and troublesome during the off-season especially if crops are subjected to a low water supply. It was reported by Barrera and Norton, (1999) that late blight is a more severe problem during rainy periods and weevil infestation during dry periods.

Insect pests

In the farms visited, the most common insect pests include: Cut Worms, Aphids, Potato Tuber Moth (PTM), Whiteflies, Stinging bugs in order of their economic severity. The insects attack potatoes in both the field and stores. Almost 87% of the respondents have a

problem as a result of Cut Worms and Aphids followed by PTM (about 82%). Although the distribution and prevalence of the insect pests are relatively different across the two Zobas, it should be noted that, they pose serious pressure in all the fields. The distribution and frequency of pests might vary depending on factors such as season of the year, location and cultivation method. As a consequence, in Zoba Maekel, PTM followed by Cut Worm and Aphids are the most prevalent insect pests with the least significant being Stinging bug preceded by Whiteflies.

The situation is quite different when it comes to Zoba Debub where Aphids followed by Cut Worms and Whiteflies are prevalent. The presence of PTM is relatively lower in Zoba Debub. This can be ascribed to the fact that first PTM are seed borne insects and Zoba Debub growers purchase their planting seeds from market with low or no own seed use which is very common in Zoba Maekel. Secondly, PTM is widely controlled through application of ample irrigation water to prevent soil cracking that allows moths to reach the tubers (CIP, 1996). Thus growers in Zoba Debub are relatively endowed with this resource. Another essential point of discussion is the relatively higher level of Whiteflies incidence in Zoba Debub. CIP (1996) reported that plant infestation by Whiteflies is often the consequence of biological imbalance resulting from the intensive use of insecticides. It was noted from the current survey that farmers in Zoba Debub relatively use more pesticides as majority are semi-commercial.

Disease pathogens

Potato hosts a number of disease causing pathogens, among which Late Blight, Early Blight, Common Rust, Fusarium Wilt, Powdery Mildew and viruses are frequently observed. In almost all the visited farms, Late Blight was noted as major disease causing pathogen followed by Common Rust and Fusarium Wilt. It was described by several authors that Late Blight is probably the single most important diseases of potato, world wide, although control measures do exist (CIP, 1996). It was also reported that the disease posed major problem for potato growers in Ethiopia, Uganda and Kenya (Gildemacher, *et al.*, 2009); Indonesia (Dawson, 2012); Asia and Pacific (Pandey, 2009). According to Tamm, *et al.*, (2004) between 50 and 100% of the interviewed potato farmers in most European countries responded that Late Blight epidemics caused significant yield losses. Under suitable environmental conditions the disease can spread rapidly and it can cause complete crop loss (Janssens, *et al.*, 2004). The authors further added that the extent of the economic damage varies depending on factors such as production systems, climate, choice of variety, soil management and use of crop protection schemes. Unless proper and timely protection system is used it will remain highly destructive. The disease becomes troublesome more during the rainy season, relatively less important in dry, hot irrigated areas. It is also favored by temperatures between 10 and 25°C, accompanied by heavy dew or rain (CIP, 1996). It is, thus,



preferable to see the spatial distribution of the disease prevalence across the regions so as to formulate appropriate and relevant control measures.

The study indicated that Late Blight ranked first in importance in Zoba Maekel and Debub followed by Fusarium Wilt in Zoba Maekel and Common Rust in Zoba Debub. In general, fungal problem is more serious in Zoba Debub than in Zoba Maekel. This might be related to the rainfall distribution between these Zobas. Zoba Debub receives higher rainfall than Zoba Maekel which exacerbates the fungal development and buildup. On the other hand, *Fusarium* Wilt incidence is higher in Zoba Maekel (70%) compared to Zoba Debub less than 20% (Figure-5). This can be accredited to its mode of transmission, that it is a seed borne disease. According to CIP (1996) report, some of the *Fusarium* strains become systemic and are seed transmitted. Most of the growers in Zoba Maekel use unrenewed own seed quite frequently, which justifies the highest prevalence of the disease. In addition, it was observed from the current study that Early Blight infection, although not seriously considered by most of the farmers, was higher in Zoba Debub (41.7%) than in Zoba Maekel (30.2%). It was also reported by CIP, (1996) that most susceptible varieties to Early Blight are the early maturing varieties showing severe defoliation, while the late maturing varieties are resistant. The current result can be attributed, therefore, to the type of varieties growing in Zoba Debub, which are usually early maturing.

Quite differently, the viral infection was higher in Zoba Maekel compared to Zoba Debub (Figure-5).

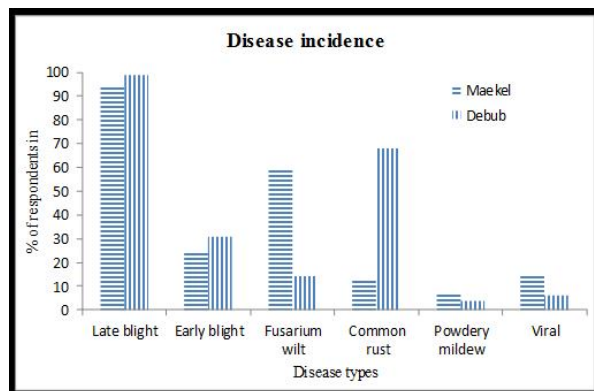


Figure-5. Common potato diseases in the two zobas.

It was also reported by Biniam and Tadesse (2008) that landrace varieties (*Tsaeda Embaba* and *Keih Embaba*) were found highly infected with viruses compared to the imported ones. This can be, attributed to the seed source and use system practiced in the two Zobas. Most of the farmers in Zoba Maekel widely use unrenewed own seed for several generations. This continuous recycling of old seeds without replenishment aggravates the situation. Hence, it is not surprising to find high levels of virus incidence in the local varieties (Biniam and Tadesse, 2008) where the seeds became safe haven to the viruses. Seed degeneration is primarily caused by several tuber-borne pathogens, the most important being

viruses and bacterial wilt (Dawson, 2012; CIP, 2011; Gildemacher, 2008). Thus, using only seed-potatoes from healthy mother plants can decrease the pressure of the disease considerably (Gildemacher, 2008; Wang, 2008).

Controlling methods

The growers attempt and use different controlling mechanisms to bring the pressure of the insects below the threshold level. Among the different approaches, chemical application followed by cultural practices are dominant, with limited numbers using physical methods. Biological method is obviously impractical and no one was observed practicing it. Majority depend on frequent application of chemicals, threatening the environmental setup of the region. To make matters worse, as previously mentioned, the type and dosage of chemicals used are neither monitored nor supervised regularly, thus, growers apply whatever seems to be easier and accessible to them. Similarly, more than 95% of the respondents, in the two Zobas attempt to control the diseases by applying chemicals. A good number of growers also use cultural practices to control spread of the disease through crop rotation, rouging out and selection of disease free seeds. Almost half of the interviewed farmers believe that the fungicides used are not efficient enough to control the disease. Thus, it is not uncommon to observe application of extra doses and frequently more than what is actually recommended. This might causes development of resistance by the pathogens in addition to the environmental pollution and increased costs of production it incurs. The timing of sprays is usually based on local experience or actual outbreak of the epidemic. Only few farmers decide when to spray based on relevant information and/or advisory services. Several farmers from Ecuador, for instance, experiment with different mixtures of chemicals until they find a perfect combination (Barrera and Norton, 1999).

Yield

Yield of potatoes in the study areas ranges from as low as 1t/ha up to 40t/ha. This range is equally reflected by both the rain fed and irrigated potato growers. Potato yield is determined both by the crop per se and the environment (Wang, 2008). This wide range of variation in yield is, thus, attributed to various factors such as variety, farming practices, inputs, location etc. This agrees with the current finding where the average yield varies across the two Zobas and season of the year. This indicates that if constraints could be overcome to some extent, it would be possible to increase the yield. Maximum yield in Zoba Debub was 40t/ha while it remained to be 30t/ha in Zoba Maekel. It was reported earlier by Bereketsahay (2000) that the locally available potato varieties produce only 5 tons per ha, but they are consistent in terms of maintaining that level of production. Furthermore, the average yield in on-season is 12 and 20t/ha while it is 10 and 12t/ha in the off-season for Zoba Maekel and Zoba Debub, respectively. This result can be attributed to the previously mentioned reasons including topography, water availability and access to resources. It's clear from this



finding that the on-season farming gives better result (14.43 ton/ha) as compared to the off-season (12.52 tons/ha) (Figure-6). This can further be explained by the fact that there is less pest pressure, especially insect pests during the rainy season and plants particularly the late

maturing genotypes get enough water to reach maturity without being disrupted. Especially in Zoba Maekel farmers mentioned that they have shortage of water during the off-season period. This finding is supported by majority of the respondents.

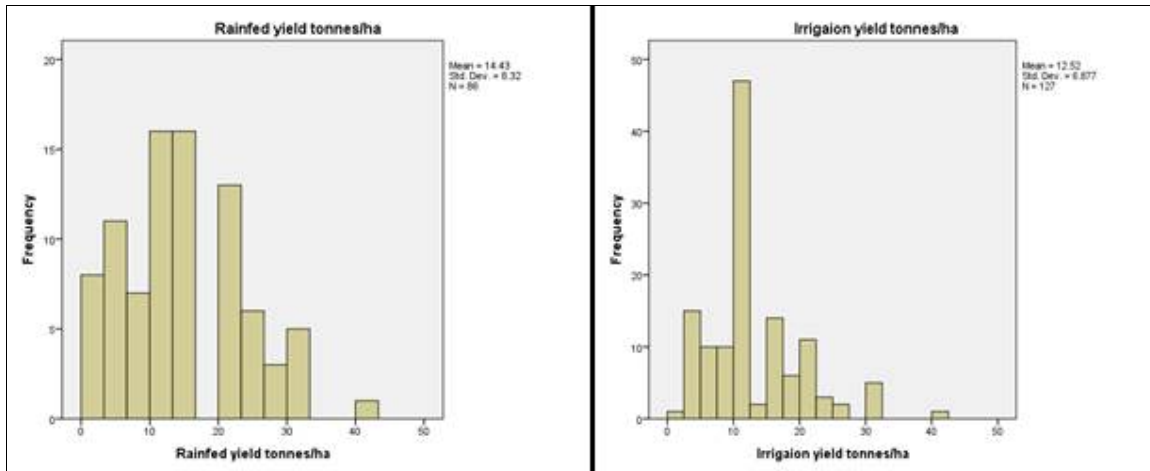


Figure-6. Yield of potato under rainfed and irrigation cultivation practices.

CONCLUSIONS

The current study revealed that potato production in Eritrea is practiced mainly by small scale farmers as food and cash crop. It is widely grown and is a priority crop for the majority of growers in the two Zobas. It's worth mentioning that more than 60% of the farmers own a land size of less than 2 ha. Most of the growers responded that they grow potato in pure stand with intensive small scale farming. Almost all the growers (91%) practice furrow irrigation system using water collected mainly from wells. It was also noted that the two most common fertilizer types used are Urea and DAP on top of the locally available farmyard manure (FYM) application. The farmers complained that there is acute shortage of farm inputs thus their main source is market with limited supply form the MoA. There is no standard and sustainable seed supply and distribution system in the country. Thus framers are obliged to use own seeds for several generations. This often accelerates the spread of seed borne diseases (viruses). Cut worm, Aphids and Potato Tuber Moth (PTM) are the main insect pests infesting the potato crop; while Late Blight, Common Rust and *Fusarium* wilt infection are among the disease pathogens posing serious yield damage. Farmers attempt to control the pest pressure using chemical means followed by cultural methods. On average, farmers responded that they obtain higher yield during the on-season compared to off-season. Analysis of the current survey revealed that average yield obtained is way below the optimum. High cost of inputs and their limited avaialbuitly are the most limiting factors for poor the potato production in Eritrea.

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