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Review

Review on major potato disease and their management in Ethiopia

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Ethiopia has possibly the highest potential for potato production of any country in Africa. However in Ethiopia, the yield per unit area of potato is very low compared to those of other countries. There are many factors that reduce the yield of the crop among which the diseases like Late Blight (LB) and Bacterial Wilt (BW) which play an important role in reduction of the yield.Hence,the objective of this review is to review the major disease of potato and their management in Ethiopia. In Ethiopia, LB is occurs throughout the major potato production areas and researches have made estimates of losses ranging from 6.5 to 61.7%, depending on levelof susceptibility of the varieties.Different types of management options like Fungicide Use, Resistant Cultivars, Intercropping,this management practice can help in reducing LB effect. However because of its new strain development, there is no single effective management strategy of this disease. Therefore adopting integrated disease management approach is the most effective, environmentally safe and low costly to the users.In addition to LB Bacterial wilt of potato can also cause significant yield loss to potato. Because of this pathogen stays in the soil for several years it prohibits subsequent production of potato in the same field. Moreover, this pathogen may stay latent without showing any symptoms in the field with the consequence of high impact on tuber yield in the upcoming season. For this disease the common control measures employed in other countries include the use of resistant variety, crop sanitation, crop rotation and other cultural practice as single or integrated disease management have met, with only limited success and on more research has been done in Ethiopia for the management of this disease. Therefore in our country more research is needed on this disease management.

Keywords: Potato, late blight, bacterial wilt, management.

INTRODUCTION

Potato (Solanum tuberosum L.) is one of mankind's most valuable food crops (FAO, 2004). It is an important food source globally. The tuber is known to supply carbohydrate, high quality protein, and substantial amounts of essentials vitamins, minerals, and trace elements. It is the most important vegetable crop in terms of quantities produced and consumed worldwide (FAO, 2005). In volume of production it ranks fourth in the world after wheat(Triticum aestivum L.), rice (Oryza sativa L.), and maize (Zea mays L.) (Bowen, 2003). Potato gives an exceptionally highyield per hectare (Feustel, 1987). World potato production increases from 30 million tonnes in 1960s to 165 million tonnes in 2007 (FAO, 2008). Potatoes are grown under a wide range of conditions - from irrigated commercial farms in Egypt and South Africa to intensively cultivated tropical highland zones of Eastern and Central Africa, where it is mainly a small farmer's crop. Ethiopia has possibly the highest potential for potato production of any country in Africa. An estimated 70% of the country's arable land is potentially

suitable for potato cultivation (FAO, 2008).Potato is a highly recommended food security crop that can helpshield low-income countries from the risks posed by rising international food prices (FAO, 2008). It is used in a wide variety of table, processed; livestock feed and industrial uses (Feustel, 1987). Potato provides nutritious food in a diversity of environments. Potato can be an important food for the increasing world population, and has the potential for increased vitamin C and protein content and increasingly a valuable source of cash income for low income farm households (FAO, 2008). In Ethiopia, the yield per unit area of this crop is very low compared to those of other countries like Rwanda, Egypt and Kenya. There are many factors that reduce the yield of the crop among which the diseases like late blight and bacterial wilt play an important role (Yaynu,1989). Therefore, the objective of this paper is to review the major diseaseof potato and their management in Ethiopia.

MAJOR DISEASE OF POTATO IN ETHIOPIA

Late blight of potato

Late blight of potato, caused by *Phytophthora infestans* (Mont. De Bary), is among the most important diseases, being especially devastating in the major potato growing areas. Serious economic consequences often result from complete or partial devastation of infected fields. Itis the most widespreadthroughout the world and causes serious tuberlosses globally (Erwin and Ribeiro, 1996; Fry andGoodwin, 1997; Garrett *et al*., 2001). Worldwide losses due to late blight are estimated to exceed $5 billion annually and thus the pathogen is regarded as a threat to global food security (Latijnhouwers *et al.,* 2004). In the past few decades, the frequency and severity of the disease have increased in many parts of the world including Ethiopia and have been a serious threat to potato production (Bakonyi *et al.,* 2002). In Ethiopia,the disease has been reported as the mostdestructive and economical disease on potato(Kassa and Hiskias, 1996). Though the effort madeby researchers to reduce the effect of the disease on tuber yield is encouraging, still the loss is very tremendous (Tarekegne and Kassa, 1997). Occurrence of *P. infestans* has been closely linked to the introduction of potato varieties in many countries of Sub-Saharan Africa. The major factors affecting potato production such as: use of susceptible varieties, diversity of pathogen virulence and races, lack of adequate disease management tactics and favorable environmental conditions have incidentally and consequently led to perpetuation and increase in late blight disease. In countries like Ethiopia where subsistencefarmers are not in a position to properly know and control the disease. In Ethiopia, it occurs throughout the major potato production areas. The area under potato is estimated more than100, 000 ha. Total failure of the cropis not uncommon. Research centers have made estimates of losses ranging from 6.5 to 61.7%, depending on the level of susceptibility of the varieties. The disease damages leaves, stems and tubers.

Factors Favoring the Diseases

In Ethiopia, throughout the country the potato crop suffers from the late blight. The climate is conducive to the growth and development of the pathogen. The main sources of the disease are cull piles, volunteer plants, seed tuber and alternate hosts. Even soil contributes to the initial inoculums. Farmers do not cut the foliage and in most cases, after the crop reaches senescence, farmers do not harvest the entire field. They use the piecemeal approach of leaving the tubers in the field for extended periods of time and harvesting as needed. These practices favor the pathogen remaining in the ground and serving as an inoculum source for the next season. Also, farmers in most areas cultivate potato as mono-crop without rotation.

These practices and the presence of alternate hosts significantly contribute to maintaining sources of inoculum in the system (Ethiopia Late Blight Profile, 2004).Ideal conditions for late blight are cool nights (50 to 60°F) and warm days (60 to 70°F) accompanied by fog, rain, or long periods of leaf wetness. Conditions must remain moist for 7 to 10 hours for spore production to occur.Variation in the incidence and severity of late blight on potato has been recorded in many locations and countries. Variability in disease incidence and severity has been reported in Kenya, Ethiopia and elsewhere in Sub-Saharan Africa countries. The variation of disease incidence and severity may be accounted for by the differences in rainfall patterns between seasons (bi-modal) and years. Variation have also been attributed to susceptibility and resistance of various varieties grown in many areas, different planting dates (disease escape), and various late blight management practices (Anonymous, 2014).

Economic Significance of the Disease

In Ethiopia the disease caused 100% crop loss on unimproved local cultivar, and 67.1% on a susceptible variety, Al-624. On station results have documentedpotato yield loss attributed to late blight in the range of 2.7 to 47% at Holeta Research Station (Bekele and Yaynu, 1996).Generally, potato yield loss attributed primarily to late blight is dependent on variety susceptibility or tolerance / resistant and disease management practices.Late blight has an impact on the industry, consumers and country (Ethiopia Late Blight Profile, 2004).It is the most devastating disease of potato

Late blight patch Late blight affected plant (Gonder region)

Source: - (Anton Haverkort *et;.al.* ,2012)
Fig: 1. Late Blight affected potato leaf and steam at Gonder region

Source: - (William kirk *et;al.,*2004*)*
Fig: 2. Late Blight affected potato tuber

Table 1. Effects of different fungicides and variety combination on marketable yield(MY),unmarketable yield (UNMY) and total yield(TY) of potato at Shashemene and Hawassa, southern Ethiopia

		Shashemene			Hawassa		
Variety	Fungicide	MY (t/ha)	UNMY (t/ha)	TY (t/ha)	MY (t/ha)	UNMY (t/ha)	T (t/ha)
Agazar	Control	13.0^{gf}	3.6^{e}	16.6^{d}	16.7^{f}	2.5^{fg}	1
	Chlorothanoil	19.0^{bcd}	2.95^{ab}	21.8^{c}	19.6^{cdfe}	2.1^{bc}	2
	Pencozeb	17.9^{de}	2.9^{b}	20.8^{c}	18.8^{def}	2.0^{b}	2
	Ridomil	20.8^{cde}	2.5^{abc}	23.3^{bc}	20.^{bedef}	1.8^{cd}	2
Guidene	Control	18.0^{de}	2.2^{cd}	20.3^{c}	19.8^{cdef}	1.2^{e}	2
	Chlorothanoil	23.6^{abc}	1.9^{de}	24.8^{bc}	23.5^{abc}	0.55^{f}	2
	Pencozeb	21.4^{cde}	2.2^{cd}	23.4^{bc}	21.0^{bcde}	0.99^{e}	2
	Ridomil	25.9^{ab}	1.8^{e}	27.7^{a}	24.0^{ab}	0.53^{f}	2
Jallene	Control	19.6^{de}	2.2^{cd}	21.8^{c}	19.4^{def}	1.75^{cd}	2
	Chlorothanoil	24.3^{abcd}	1.8^{e}	26.0^{ab}	22.6^{abcd}	1.2^{e}	2
	Pencozeb	22.8^{cde}	1.9^{de}	24.5^{bc}	22.1^{abcde}	1.0^{e}	2
	Ridomil	30.1^{a}	1.7^{e}	31.8^{a}	25.1^{a}	0.95^{e}	2
Whiteflower	Control	16.0^{e}	2.9^{ab}	18.9^{cd}	16.8^{f}	2.4^{a}	1
	Chlorothanoil	21.4^{cde}	2.3^{c}	22.6^{bc}	22.2.^{abcde}	2.0^{bc}	2
	Pencozeb	19.5^{de}	2.3^{c}	21.8^{c}	20.2^{bedef}	2.1^{b}	2
	Ridomil	22.0^{cde}	2.2^{cd}	24.3^{bc}	22.1^{abcde}	1.6^{d}	2
CV		10.5	10.3	10.2	11.3	14.5	1
LSD (5%)		3.00	0.38	3.38	3.35	0.29	3.

Mean in a column followed by same latter are non-significant different
Source :-(H. Kefelegn, *et,.al.*2012)

in countries like Ethiopia where subsistence farmers are not in a position to properly know and control the disease.In Ethiopia, it occurs throughout the major potato production areas. The area under potato is estimated more than100, 000 ha. There are five major potato production regions in Ethiopia such as Central Ethiopia, Eastern Harerge, Northwest Ethiopia, South Ethiopia and Western Ethiopia.In the central (Ginchi, Jeldu, Galessa and other districts, which are located in an altitude greater

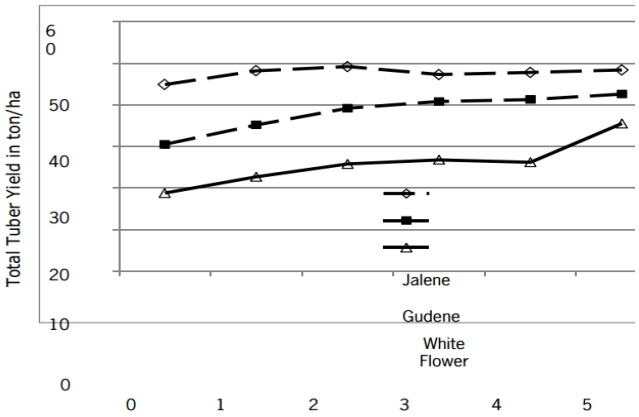

Fig: 3. .the yield from the trail in Awassa
Source: (Anton Haverkort, *et;.al.* 2012).

Table2. Late blight–resistant varieties released in 2002

CIP Number	Proposed Name	Adaptation
384321.19	Jalenea	Wide adaptation
387792.5	Degemegne	Wide adaptation
384321.9	Guasa	Regionally released for North Western Ethiopia from Adet Research Centre
382173.12	Gorebela	Regionally released for North Shewa from Sheno Research Center

Source : (Ethiopia Late Blight Profile, 2004).

Table 3. Importance of bacterial wilt in some African country

Country	Races (Biovars)	% Crop losses (% wilt incidence)
Burundi	3 (2-A)	30 – 50
Ethiopia	2 (2-A)	(45)
Kenya	1, 3 (3, 2-A, 2-T)	50 – 75 (seed)
Rwanda	3 (2-A)	-
Uganda	2 (2-A)	26 - 100

Source: (T. Sengooba and J.J. Hakiza, 2014).

than 2800 masl) highlands there is narrow diversification of crop species in rotation to cereals and pulses (such as barley, wheat and to some extent faba bean)

In this part of the country, most of the farmers grow potato as a garden crop without rotation, but in areas like Shashemene (the major supplier of fresh ware potato to the capital city) potato is grown as a field crop under short rain with supplementary irrigation and /or under irrigation. In the eastern part of the country, it may be planted as relay cropping. During the long rains (June – September) and the short rains (March – May), potato is often intercropped with cabbages, sorghum, beans, maize, eggplant, or tomato.

In other parts of Ethiopia, particularly in the eastern part of the country, strip cropping with cabbage may be done under irrigation conditions. In the northwest part of the country potato is the major field crop and has a significant role in the food system of the farmers in the region. In the western part of Ethiopia, although the crop used to be important in the cropping system, due to late blight disease farmers have almost stopped cultivating potato (Ethiopia Late Blight Profile, 2004).

In Ethiopia potato production is mainly dependent on natural rainfall and smaller proportions of areas the crop is supported by irrigation. Due to the unfortunate shortage of rain in both main and short rain season's potato production was highly reduced throughout the country in 2002. As to the previous years the potato yield has been seriously affected by late blight but during 2003 the disease coupled with the shortage of rain shower that was occurred throughout the country, the yield per unit area and total production was significantly reduced. As a result there was a serious shortage of fresh potato in the local markets and about 50% higher comparing to year 2002 raised the price. Small industries were also seriously affected because of scares in supply. Farmers in marginal potato growing areas whom were partly or fully dependent on potato to feed their family and for market use (Anonymous, 2014).

Major Management Methods Used

Fungicide Use

At a global level, the major approach to prevent late blight development has been application of fungicides.The first spray with Ridomil MZ 63.5% wp at a rate of 2 kg/ha and followed by 2-3 sprays (need base application) of Dithane M 45 at a rate of 3 kg /ha were found to be effective in controlling late blight (Ethiopia Late Blight Profile, 2004).

Bekele K. and Hailu B. (2001) had done a research on the efficacy and economics of fungicide spray in the control of late blight of potato in Ethiopia. The result showed that, Ridomil MZ - 63.5% WP which is both systemic and protectant in action gave the best control (78.8%). On the other hand Chlorothalonil, Mancozeb and Brestan 10 did not differ significantly in respect to disease control, and gave 59.3, 43.0 and 46.8% control, respectively. However, the three fungicides significantly ($P< 0.05$) controlled late blight when compared to the control plot. They conclude that, the fungicides Chlorothalonil 50% EC and Brestan 10 can be used to control late blight. Overall, Ridomil MZ 63.5% WP gave effective control of late blight and the best return. In addition farmers frequently applythis fungicides to control late blight but the economic benefit accruing from the fungicide spray have not been established (Bekele and Hailu 2001). Binyam et;al. (2014a) also reported that, reduced rates of Ridomil application resulted in better management of potato late blight with the highest marginal rate of return. Therefore, those potato growers who can afford to buy it can use it as an alternative fungicide in late blight control. Although the use of fungicides at government control prices level was economic, lack of experience in use of fungicides and availability of sprayers are obstacles that hinder the use of the technology.

Studies conducted in Uganda, Kenya and Ethiopia on Fungicide and variety reaction suggests that significantly late blight control can be achieved when the protectant fungicide, Dithane (a.i mancozeb) is applied on a scheduled basis. On-farm research also indicates that three timely applications of a protectant or a protectant fungicide alternated with systemic fungicide can be effective for late blight management (PRAPACE/CIP, 1996).

Resistant Cultivars

In Ethiopia Before few years 29 varieties have been released officially to the Ethiopian market. Most of these originate from EIAR-CIP breeding program (Mekononen *et.,al*. 2011) including three varieties with different late blight resistance in their trails. The varieties Jalane, high level of resistance and Gudene moderate resistance were released by Holota agricultural research center in 2006. Further the local variety, white flower, highly susceptible to late blight.

Other Late blight–resistant varieties have been released over the years. Below are varieties from CIP population A, which were released in 2002.

Otherreleased improved variety Menagesha has lost resistance to late blight, but still is one of the best varieties in the high altitude areas (>2800 masl) if supported by reduced fungicide application and early planting (Integrated Disease Management, IDM). The remaining improved varieties such as Tolcha and Wechecha better express their yield potential when accompanied with IDM (Ethiopia Late Blight Profile, 2004).

Intercropping

In the central highland of Ethiopia, potato is a garden crop and intercropping with brassica at a lower population being an ordinary practice but crop like garlic is also grown as a sole crop in the same garden. Of the various options available in the high altitudes, cropping systems,

other than so many advantages related to intercropping mentioned elsewhere, disease problems is low in an intercropping production systems compared to sole cropping production system(Ethiopia Late Blight Profile, 2004).

Aresearch done on the effect of intercropping on potato late blight, *Phytophthora infestans* (Mont.) de Bary development and potato tuber yield in Ethiopia. The result prevailed that, all potato-garlic ratios exhibited superior performance when compared to the fungicide unsprayed treatment. Among the proportions, 75% garlic with 25% potato (3:1) intercropped plots showed significantly ($p< 0.05$) low disease development and high tuber yield. Moreover, at 3:1 combination of garlic to potato the land equivalent ratio (LER) was greater than 1 and the monetary values were high at both testing sites. Significant ($p< 0.05$) differences were also observed among potato varieties with regards to the disease development and tuber yield. The study also demonstrated that fungicide treatment provided significant low ($p<0.05$) disease development and higher potato tuber yield when compared to the untreated monoculture control treatment. The findings of this study suggested garlic as a potential intercropping plant for the management of potato late blight disease under Ethiopian condition (Anonymous, 2014).

Bacterial wilt

Bacterial wilt of potato (Ralstonia solanacearum) can also cause significant yield loss to potato .Because this pathogen stays in the soil for several years it prohibits subsequent production of potato in thesame field. Moreover, this pathogen may stay latentwithout showing any symptoms in the field with the consequence of high impact on tuber yield in the upcoming season. Detection of latent infections by R.solanacearumrequires sensitive diagnostic methods but,as yet, such methods have not been adopted in Ethiopiato inspect potato seed tubers and monitor the status of latent infection and its consequences. As the crop isvegetative propagated, the diseases can easily be transmitted through tuber and cause very high economy losses across wide geographic areas(Anonymous, 2014).

It is also known as brown rot is caused by *Ralstonia (Pseudomonas) solanacearum* E. F Smith, a soil-borne bacterial species. Bacterial wilt is one of the most destructive plant diseases which arepredominantly distributed in the tropical, subtropical and warm temperate regions of the world(Hayward, 1994). It affects as many as 200 plant species representing more than 50 families ofparticularly members of solanaeceous plants such as potato, tomato, eggplant, pepper andtobacco. In Ethiopia, *R. solanacearum* is one of the most important pathogens (Yaynu, 1989).

Factors Favoring the Disease

The pathogen can survive for various periods of time in the soil, depending on the conditions to which it is subjected. *Ralstonia solanacearum* can survive in the soil for a few months to a few years. Wet soil conditions and moderate temperatures usually favor the survival of the bacteria. Moreover, plant debris and rotting tubers help the pathogen to survive from season to season in the absence of host crops (Elsas *et al*., 2000).*R. solanacearum* race is more adapted to cooler climates but its virulence and density will decline when temperatures drop below 15°C and drastically below 4°C (Stansbury *et al*., 2001). Therefore, long-term survival ability of the brown rot pathogen in soils of temperate countries is significantly reduced.*R. solanacearum* can spread in waterways, and is known to survive for long periods of time in water. Contaminated irrigation waters help in the spread of the pathogen from field to field (Hay, 2001). Some weeds can act as reservoir plants allowing the pathogen to survive, multiply and spread to contaminate new lands. *Solanum dulcamara* has been identified as a host for *R. solanacearum* race (Elphinstone, 2001). Like almost all bacterial phytopathgens, *R. solanacearum* enters into plants via wounds made by tools during post emergence cultivation, and by nematodes and insects in the soil or natural openings. Once inside the plant, the bacteria will move preferentially towards the vascular bundles to finally colonize the xylem. The presence of the bacteria inside the xylem coupled with the production of exopolysaccharides will block the vascular vessels inducing a water shortage throughout the plant. This causes the plant to wilt and eventually die (Poussier *et al*., 2003).

Economic Significance of the Disease

The economic implications of *R. solanacearum* are yet to be fully understood. This is further complicated by the fact that yield losses are influenced by many factors like host, cultivar, climate, soil type, cultural practices and the bacteria itself with some strains being more virulent than others. It is the second most important constraint to potato production in tropical, subtropical and warm temperate regions of the world. It may also occur in cooler climates such as at relatively high elevation in the tropics or higher latitudes(Ethiopia Late Blight Profile, 2004).

In the case of Potato, losses are more significant since this crop is a staple food for millions of farming communities around the world. It is currently estimated that bacterial wilt of potato affects 1.5 million Ha of lands in 80 countries and induces a global cost of $ 950 millionannually .In some countries losses are outstanding; in Bolivia many reports stated that yield was reduced from 30-90% and almost all tubers (98%) were lost during storage. In similar manner the problem of potato bacterial wilt in Africa is associated with serious yield loss (Anonymous, 2014).

In Ethiopia, bacterial wilt has been recorded on potato, tomato and eggplant in many regions (Yaynu, 1989). Stewart (1956) first recorded the disease in 1956 on potato and eggplant in Keffa region (South West Ethiopia). Stewart and Dagnachew (1967), in their index of plant disease in Ethiopia, listed bacterial wilt on potato, tomato and eggplant in Keffa (South Ethiopia) and on potato in Arsi and Shewa (Central Ethiopia). Other workers observed bacterial wilt on potato in Ethiopia. According to Yaynu (1989) Anonymous (2014) stated that indicated that bacterial wilt is an important disease of potato and tomato in many parts of Ethiopia and sometimes in the past the disease caused heavy losses at some commercial farms including at the potato seed tuber multiplication farm, Tseday Farm in Central Ethiopia, as a result of which potato seed tuber multiplication in the farm has been abandoned. Moreover, pepper plants infected by *R. solanacerum* have been observed in Ethiopia recently.

MANAGEMENT METHODS

Bacterial wilt is caused by a pathogen that isn't easily managed. There is need for more research on the epidemiology and the host-pathogen interaction in order to devise the most appropriate management strategy. Currently, several control options can be investigated and an integrated management strategy may be set-up based on local needs.The common control measures employed in other countries include the use of resistant variety, crop sanitation, crop rotation, selection of disease free planting material and other cultural practices as single or integrated disease management have met, if at all, with only limited success. However, control through the use of resistant varieties alone has yielded little success. This is because such kind of resistance is strain specific and liable to break down by virulent and highly polymorphic strains of *R.solanacearum* at ambient temperature and in nematode infested soil (Prior *et al*., 1994). Successful control of the pathogen through crop rotation is also not always effective since rotation practices recommended for one area may not perform well at other locations in addition to differences in the strains involved (Prior *et al*., 1994). However, much research has not been done on this disease in Ethiopia. The following Biological control methods have been researched in Ethiopia.

Biological Control

The use of rhizosphere resident microbial antagonist specifically the fluorescent *pseudomonas* is noted as a promising control method. The rhizosphere is a habitat in which several biologically important processes and interactions takes place which is primarily due to the influx of mineral nutrients from accumulation of plant roots exudates through mass flow and diffusion. Among the rhizosphere organisms, fluorescent *pseudomonas* strains are often selected for biological control strategies because of their ability to utilize varied substrates under different conditions, short generation time and motility that assist colonization of rootsAnonymous, 2014).

Henok *et al.,* (2007) evaluate Ethiopian isolates of *Pseudomonas fluorescens* as biocontrol agent against potato bacterial wilt caused by *Ralstonia (Pseudomonas) solanacearum.* Three isolates of *Pseudomonas fluorescens* i.e., PfS2, PfWt3 and PfW1 showed inhibition against the growth of the pathogen. Bacterization of tubers with isolates Pf S2, Pf Wt3, and PfW1, significantly reduced by 59.83% the incidence of bacterial wilt compared to the pathogen-inoculated control and increased plant growth (plant height and dry weight) by 59.83%, 76.89% and 28.44%, respectively. This suggests the importance of the studied isolates as plant growth-promoting rhizobacteria.

Lemessa (2006) working on biochemical, pathological and genetic characterization of strains of *Ralstonia solanacearum (Smith)* from Ethiopia and biocontrol with bacterial antagonists found that the most effective strains *(Pseudomonas fluorescent* APF1 and *Bacillus subtlis* B2G) consistently reduced wilt diseases and increased plant weight significantly. The Pseudomonas APF1 strain showed the greatest plant growth promotion effect, increasing plant dry weight up to 63% compared to the untreated control. Generally, plant protection rendered this way can be maximized by combining different methods in an integrated disease management approach such as resistant variety and biocontrol

SUMMERY AND CONCLUSION

Potato (Solanum tuberosum L.) is the fourth major crop of the world after rice, wheat and maize. In Ethiopia, the yield per unit area of potato is very low compared to those of other countries. There are many factors that reduce the yield of the crop among which the diseases like late blight and bacterial wilt which play an important role. Therefore understanding its development, epidemiology and life cycle are most important in selecting and implementing its effective management strategy. Management of these diseases is therefore very essential. However, much research has not been done in Ethiopia for the management of bacterial wilt of potato disease. But in case of late blightthere are different types of management options of which can help in reducing its effect. But because of its new strain development, there is no single effective management strategy of this disease. Therefore, adopting integrated disease management (IDM) approach is the most effective, environmentally safe and low costly to the users.

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