Status of Bacterial Wilt Disease in Major Potato Growing Areas in West Shewa and West Arsi Zones, Ethiopia

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Abstract

A field survey was carried out in major potato growing areas in West Arsi and West Shewa administrative zones, Ethiopia, to determine the incidence of potato bacterial wilt (BW) caused by *Ralstonia solanacearum*. Limited information is available on *R. solanacearum* causing potato wilt in these areas. Stem and tuber samples with bacterial wilt-like symptoms were collected from 13 locations in 67 fields for serodiagnosis of the pathogen. BW incidences were higher in West Arsi than West Shewa zone based on both visual field disease assessment and serological assays. Relatively, high disease incidences were observed in Shashamene, Guder, Kofele and Ambo areas, with *R. solanacearum* wilt incidences of 73%, 69%, 67% and 67% respectively. The least *R. solanacearum* wilt incidence was recorded at Wonchi and Tikur-Enchini (20 % each). Improved potato cultivars such as Jalene, Gudane, Argane, Tolcha and Key-Ababa were more vulnerable to *R. solanacearum* compared to locally used potato varieties. Altitudes of the surveyed locations had negative correlations with a BW incidence. The higher occurrence of *R. solanacearum* is probably due to farmers recycling of infected potato tubers, cropping system, overlapping of potato growing seasons, abundance of the root knot nematodes and infected volunteer potato from previous seasons. The warmer and humid climate in lower altitudes might have also favored higher incidences of *R. solanacearum*. Overall, more than 54.4 % of the assayed samples were tested positive for *R. solanacearum*, and 37.7 % symptomatic samples were tested negative, indicating the presence of other agents causing BW-like symptoms. Current crop yield losses due to this disease need to be quantified with independent studies so as to ascertain the magnitude of the problem in these areas.

Key words: Bacterial wilt incidence, NCM-ELISA, Potato, *Ralstonia solanacearum*, Survey

Introduction

Ethiopia is one of the mojar potato (*Solanum tuberosum L.*) producers in Africa, with 70 % of its arable land in the high altitude areas between 1500 - 3,000 meters being suitable for potato production [Food and Agricultural Organization Statistical database (FAOSTAT), 2008]. It is mostly grown in the central, southern, northwestern and eastern highlands of Ethiopia that accounts for about 83 % of the potato production in the country. The central potato growing zones are mainly West Shewa and North Shewa, and the southern potato growing areas include West Arsi zone in Oromia and Gurage, Gamo Goffa, Hadiya, Wolayta, Kambata, Siltie and Sidama zones in the Southern Nations, Nationalities and Peoples' Regional State (SNNPRS). Northwestern potato production area is located in Amhara regional state whereas the eastern area covers the eastern highlands of the country, mainly the East Harerge zone (CSA, 2008/2009). The total area under potato production is estimated to be 160,000 hectares (ha) with an annual production of 1.28 million tons (FAOSTAT, 2008).

There are many factors limiting potato production in Ethiopia, of which fungal, viral and bacterial wilt diseases appear to be significant constraints (Bekele *et al.*, 2011; Adane *et al.*, 2010). Recently, evidence has been presented that *Ralstonia solanacearum* is the main causal agent of potato bacterial wilt in tropical, subtropical, and temperate regions (Lemessa and Zeller, 2007; Mwangi *et al.*, 2008). Yield losses due to rotting of tuber in these regions are estimated to be 1.52 million ha in about 80 countries with global damage estimates exceeding USD 950 million per year (Elphinstone, 2005). According to the same author potato brown rot has been reported from ten African countries including Burundi, Egypt, Ethiopia, Kenya, Libya, Reunion, Rwanda, South Africa, Tanzania and Uganda with serious economic losses. Kenyan potato yield loss is about 50 - 100 % in traditional potato producing areas (Ajanga, 1993). In Ethiopia, *R. solanacearum* is a threat to potato and tomato productions mainly in irrigated farm lands. Disease incidences of 63 % on potato and 55 % on tomato were reported in major potato growing areas (Bekele, 1996).

Now a days, increase in potato farms and potato demands in Ethiopia need improvement of the quality of seed potato and ware potato production systems which require better information about biotic and abiotic stresses that affect potato yield. Information of *R. solanacearum* potato wilt is currently insufficient in Ethiopia though some reports have shown incidences of bacterial wilt in a few locations in the country (Bekele *et al.*, 2011 and Lemessa and Zeller, 2007). To suggest options for a proper management and to design appropriate control measures, knowledge of the pathogen existence, distribution and occurrence are important points that should be addressed. Hence,this study was conducted to assess incidence and the current status of bacterial wilt in the major potato growing areas in West Shewa and West Arsi administrative zones, Ethiopia.

Materials and Methods

Sample collection

A survey was conducted in two important potato growing administrative zones (West Arsi and West Shewa) in Oromia regional states, Ethiopia (Fig. 1). The sample domains were purposely selected to represent the major potato producing zones from warmer areas in the Ethiopian Rift Valley and relatively cooler highland areas of the country. Major potato growing locations were selected by consulting agricultural office of the zones.

Sample collection was conducted during short rainy season (January - August, 2012), mainly in irrigated potato farms. The average distance between two nearby randomly sampled fields was 5 km, and 5 - 12 plant samples per field were collected during the field visits. A total of 488 samples (stem and tuber) from 67 fields were collected for laboratory analysis. The stem bacterial wilt assay was compared with its corresponding tuber sample tests. The crop was at flowering and tuber setting stage (about 9 - 11 weeks) during sample collections. BW like symptomatic and non-symptomatic samples were collected from seed potato farms, ware potato farms and experimental plots with more emphasis given to symptomatic ones (Table 1). Sampling was performed with a simple random sampling technique followed by diagonal sample collections in a sampling area of 20 m^2 (4 m x 5 m). The number of samples collected from each field depended on the diversity and distribution of the symptoms in the respective potato fields.

During potato field inspections, information related to source of seed potato tubers, growth stage and potato cultivars, disease symptoms, field disease incidences, disease management practices, the purpose of production (ware, seed or research), altitude, geographical position and field sizes of the representative study areas were recorded.

Preparation of stem extracts and enrichment

The main stem of the sampled plant was separated from other stems, thoroughly cleaned with tap water and cut at the point of the uppermost roots to get about 5 - 10 cm fragment from the other end. The segments were disinfected in 1% sodium hypochlorite for 5 min, then rinsed with sterile distilled water and allowed to dry on clean tissue paper. About 3 cm of the lower and upper parts of the fragment were cut off and discarded, and the remaining fragment was chopped and extracted in a plastic bag by crushing the tissues with a wooden roll. Extractions were performed in 1:2 (w/v) ratio of sample to citrate buffer (pH 5.6) at room temperature. Five hundred microliters of the supernatant extracts were, then, added to 0.5 ml of modified semi-selective medium South Africa (M-SMSA) broth in 1.5 ml Eppendorf tube for enrichment at 30 ^{0}C for 48 hr with manual agitations twice a day.

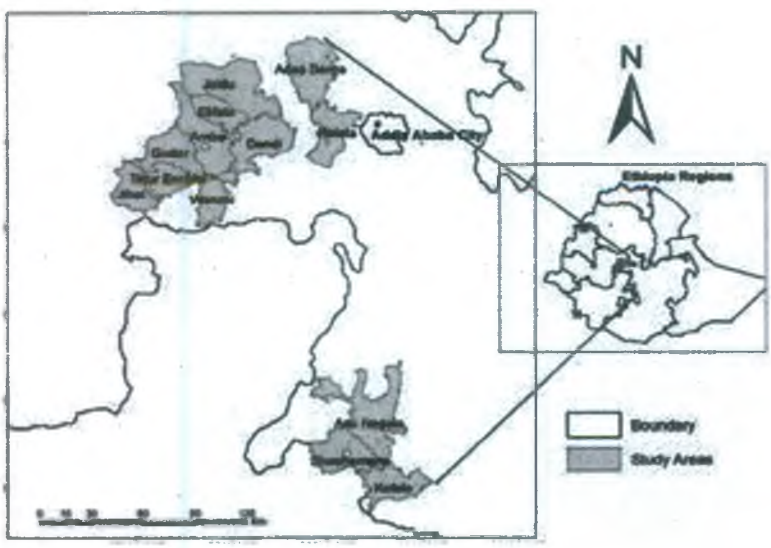


Fig. 1. Map of Ethiopia showing study areas in central Ethiopia

Preparation of tuber extracts and enrichment

From each plant 3 - 5 tubers were collected and washed with tap water to remove soil. Tubers were then soaked in 1% sodium hypochlorite for 5 min, rinsed with sterile distilled water and allowed to dry on clean tissue paper. A thin slice of each tuber was removed from the stolen end with sterile scalpel. About 3 mm x 3 mm strips, along with vascular rings, were removed and combined in a separate clean bag. Then composite of the vascular rings were crushed, extracted and enriched as stated for stem extracts.

Serological assays

The serological detection of *R. solanacearum* was carried out according to standard protocols in CIP (International Potato Center) NCM-ELISA (Nitrocellulose Membrane - Enzyme Linked ImmunoSorbent Assays) kit instruction manual (Priou *et al.*, 1999). Twenty microliter of an enriched aliquot of the stem or tuber extracts was dotted on a nitrocellulose membrane. Then, the membrane was soaked in blocking solution (0.43 g non-fat powdered milk, 30 ml TBS (2.42 g Tris, 29.22 g NaCl, 0.1 g NaN_3 per liter) and incubated for 1 hr with gentle agitation. After discarding the blocking solution, the same amount of Rs-specific antibody solution (0.43 g antibody buffer, 30 ml TBS and 100 µl IgG-Rs) was added to Petri dish and incubated for 2 hr with gentle agitation. Unbounded Rs-antibodies were removed by washing the membrane 3 times with 30 ml Tween-TBS (T-TBS) with constant agitation at 100 rpm. Thirty milliliter of conjugate solution (0.43 g conjugate buffer, 30 ml TBS, 100 µl conjugated goat anti-rabbit antibodies) was added and incubated for 2 hr. Unbounded conjugated goat anti-rabbit (GAR) -IgG was removed by washing the membrane 3 times with 30 ml Tween-TBS (T-TBS) with constant agitation at 100 rpm. Finally, the membrane was soaked in 25 ml of color development solution (substrate buffer pH 9.8, 100 µl Nitro blue tetrazolium (NBT) and 100 µl Toluidine salt of 5-bromo, 4-chloro, 3-indolyl phosphate (BCIP) and allowed for 15 min reactions to take place. CIP positive (at concentrations of 10^6, 10^7, 10^8 bacteria / ml) and the negative control strip was included for each test.

Data analysis

Field disease incidence was stratified based on symptomatic plant samples, and incidence of *R. solanacearum* infection was expressed as the Percentage of *R. solanacearum* infected plant samples (Pratim and Mandal, 2009).

Then, the obtained data were analyzed using Statistical Package for Social Science (SPSS) version 17 software to determine means and percentages. Least significant differences (LSD) of mean separations at 5% confidence interval and correlation coefficients were analyzed by student's t-test.

Results

Field diagnosis

The common BW-like symptoms observed during field survey include wilting of the leaves at the end of branches, pale-yellowing of lower leaves; oozing from potato eyes and adhering of soil when ooze dries; browning of stem vascular tissues and oozing of milky fluid from vascular rings of the cross-sectioned tubers (Fig. 2 A - D). Bacterial wilt like-symptoms were observed in majority of the inspected potato fields, representing fields surveyed in the two administrative zones. Field disease incidences varied between the two zones, among locations within a zone and even among sampled fields within a location. It was generally higher in West Arsi zone compared to West Shewa zone. The disease occurrences in the surveyed areas ranged from 4 to 43 % depending on the potato sampling sites, the purpose of productions and potato cultivars. The highest field disease incidence was recorded at Shashamne (43 %) followed by Arsi-Negele (42 %), Kofele (41 %) and Guder (36%), and the least field disease incidence were observed at Tikur-Inchini (4 %) in seed potato producer's cooperatives field. Overall, the disease incidences were less in seed potato farms (farmer's seed potato field and seed potato producer cooperatives) compared to ware potato farms and variety trial experimental plots.

In many of the sampled areas (4 m x 5 m quadrant), within a surveyed field, field disease incidence were recorded between 16 - 25 % except at Tikur-Inchini and Holetta where the disease occurrences were less than 5 % and between 5 - 15 %, respectively. At Tikur-Enchini three of the sampled areas were non-symptomatic to BW like diseases, and 56 - 65 % BW like symptoms was recorded at Ambo and Guder sampled areas. One third of the sampled areas at Kofele, Shashamene and Arsi-Negele had more than 65 % incidence of bacterial wilt like symptoms. Two of eight sampled fields at Guder (two experimental plots) were 100 % symptomatic to BW like disease (Table 1).

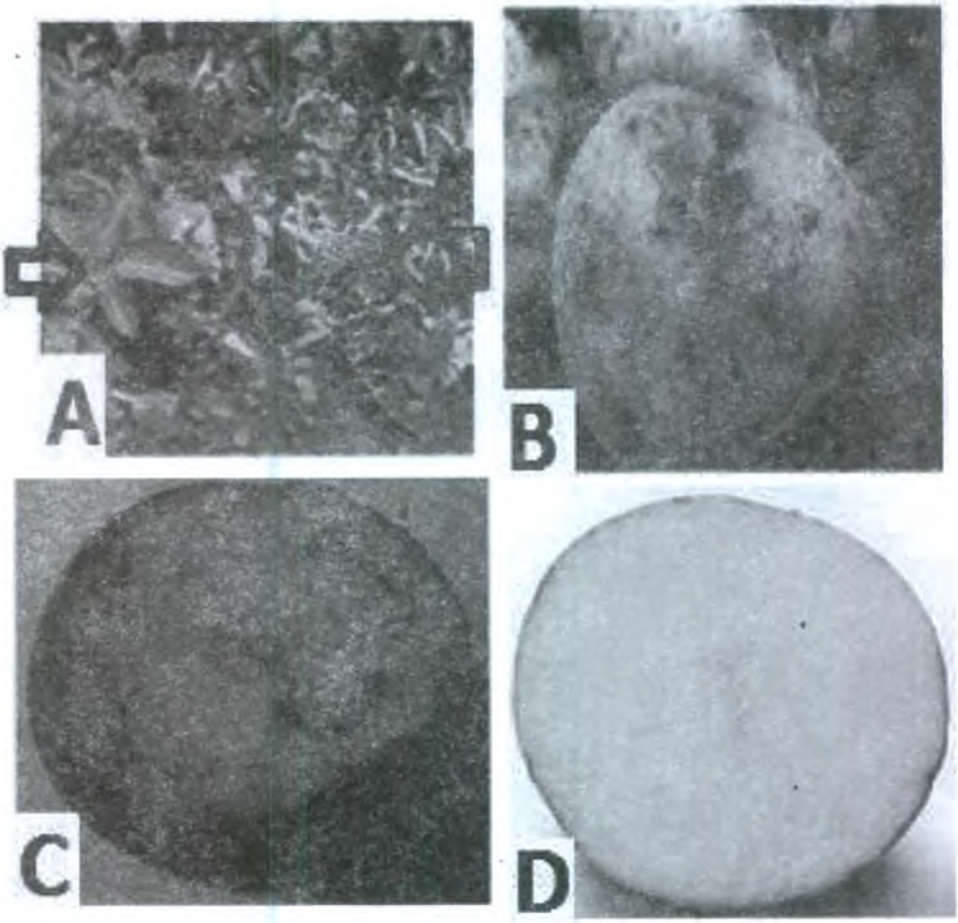


Figure 2. Some of the bacterial wilt like symptoms observed during field survey. A, Asymptomatic healthy looking (Blue arrowhead) and wilted potato plant (Red arrowhead); B, necrosis of a potato tuber; C, Transverse section of a potato tuber with necrotic vascular rings; D, Transverse section of healthy looking potato tuber

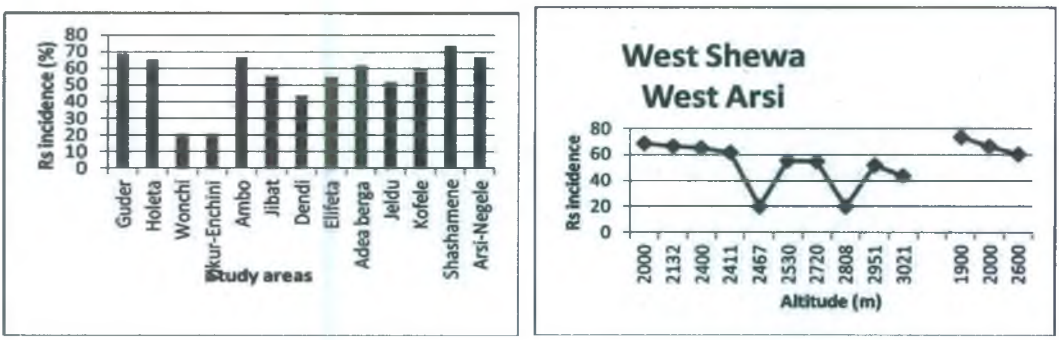
Table 1. Bacterial wilt-like disease incidence based on observed symptoms in farmers' potato fields and experimental plots in West Shewa and West Arsi zones, Ethiopia, during short rainy seasons, 2012.

Zone	Surveyed Areas	Farm type[a]	No. of fields	No. of samples	No. of sampled area with disease incidence (%) of:								
					<5	5-15	16-25	26-35	36-45	46-55	56-65	>65	FDI
West Shewa	Guder	*EP/FF	8	70	1	13	23	12	6	7	3	3+2**	36
	Holetta	FF	5	23	9	10	3	1					
	Wonchi	FSPE	2	10	4	3	3						7
	Tikur-Enchini	SPPC	2	10	6	4							4
	Ambo	FF/FSPF	10	96	7	25	28	15	14	4	3		26
	Jibat	FF/FSPF	6	58	8	20	23	4	3				19
	Dendi	FF/FSPF	12	94	15	31	34	9	5				12
	Elifeta	FF/FSPF	5	44	4	14	16	8	4				16
	Adea berga	FF	2	13	3	2	4			4			33
	Jeldu	FF/FSPF	3	25	7	5	9	4					14
West Arsi	Shashmene	FF/FSPF	4	15		3	5					6	43
	Kofele	FF	4	15		3	3		2	2		5	41
	Arsi-Negele	FF	4	15	2	1	5	2				5	42

[a] EP, Experimental Plot; FF, Farmers' ware potato field; FSPF, Farmers seed potato field; SPPC, Seed Potato Producers Cooperatives; FDI, Field disease incidence; Sampled area, 4 m x 5 m quadrant; *, Bacterial wilt-like symptoms free sampled areas; **, 100 % bacterial like symptomatic experimental plot. The numbers of sampled areas were equal to the total number of samples collected from each surveyed fields. That is, from each quadrant one sample was collected for serological test. a, Five experimental plots sampled at Guder research station. Each of the experimental plots was considered as a field and field disease incidence was recorded per plot.

Bacterial wilt incidence

A total of 488 samples (stem and tuber) were collected from 67 fields in the study areas (Table 1) to assay for R. *solanacearum* wilt (RsW) incidences. On average, 67 % of the RsW occurrence was recorded in the West Arsi administrative zone, of which 73 % incidence was observed at Shashamene surveyed fields. Kofele and Arsi-Negele had disease incidences of 67% and 60% of the tested samples, respectively. On the other hand, on average 51 % incidence of RsW was observed in samples collected from West Shewa zone. In this zone, the highest incidence was recorded at Guder (69 %) followed by Ambo (67 %), Holetta (65 %), Adea-Berga (62 %), Jibat (55 %), Elifeta (54.5 %), Jeldu (52 %) and Dendi (44 %). The least RsW disease incidence was recorded at Wonchi and Tikur-Inchini (20 % each) (Fig. 3 A). The result revealed that RsW incidence was significantly higher in the West Arsi zone than West Shewa zone. Apart from Tikur-Inchini and Wonchi, more than 20 % of apparently healthy looking potato samples were infected with *R. solanacearum* in all surveyed fields. Both symptomatic (r = 0.68) and non- symptomatic (r = 0.64) tested samples had positive correlation with BW field disease incidences. Overall, more than 60 % and 30% of symptomatic and non-symptomatic assayed samples were respectively tested positive for *R. solanacearum* infection (Table 2).



(A) (B)

Figure 3. Bacterial wilt incidence (%). A, Incidence of NCM-ELISA detected *R. solanacearum* potato samples collected from 13 study areas in West Arsi and West Shewa administrative zones, Ethiopia. B, Influence of altitude on bacterial wilt incidence. Each sample was considered positive when tuber and its corresponding stem samples were infected with *Ralstonia solanacearum*

The *R. solanacearum* assayed samples showed four categories of BW status: positive in stems only, positive in tubers only, positive both in stems and tubers and negative both in stems and tubers (Table 3). On average, more *R. solanacearum* positives in stems only than *R. solanacearum* positive in tubers only were observed in samples collected from Guder, Jibat, Elifeta, Adea Berga and Jeldu areas studied, and vice versa for samples collected from Holetta,

Wonchi, Ambo, Dendi and Arsi-Negele. At Tikur-Inchini and Shashamene areas studied, no sample with either *R. solanacearum* positive in stems only or *R. solanacearum* positive in tubers only was recorded. The mean percentage of the *R. solanacearum* positive in stems only and *R. solanacearum* positive in tubers only were, however not significantly different. Some of the assayed samples were tested negative for *R. solanacearum* infection in all inspected fields.

The incidence of R. *solanacearum* wilt at different altitude is shown in figure 3 B. Except at Wonchi and Tikur-Inchini (West Shewa), RsW disease incidences decreased with increase in altitudes in both West Shewa and West Arsi administrative zones.

In spite of some limitations to study potato cultivars susceptibility to *R. solanacearum* at field levels, vulnerability of improved potato cultivars to this pathogen was evaluated to find out the situation for further investigations. In many potato fields where improved and local potato cultivars grown, improved potato cultivars (Jalene, Gudenie, Menagesha, Argane, Tolcha and Key-Ababa) were more prone to pathogen damage as compared to locally used potato varieties. Argane and Key-Ababa varieties were the most susceptible cultivars to this pathogen in West Shewa and West Arsi administrative zones, respectively. cv.Jalene had a similar RsW incidence in both West Shewa and West Arsi administrative zones, while cv. Gudane was slightly more infected in West Arsi than in West Shewa zone (Fig. 4).

Table 2. BW incidence (%) determined by NCM-ELISA in symptomatic and non-symptomatic potato samples and their correlation with BW field disease incidence*

Study areas	FDI	No of symptomatic assyed samples	Rs infected	No non-symptomatic assayed samples	Rs infected
Guder	36	52	78.8	18	33.3
Holeta	13	20	70	3	33.3
Wonchi	4	8	25	2	0.0
Tikur-Inchini	3	8	25	2	0.0
Ambo	26	62	79	34	32
Jibat	19	36	66.7	22	36.4
Dendi	12	65	46.2	29	52
Elifeta	16	30	66.7	14	28
Adabarga	33	9	77.8	4	20
Jeldu	14	17	64.7	8	37.5
Kofele	41	13	61.5	2	50
Shashamene	43	13	76.9	2	50
Arsi-Negele	42	12	66.7	3	66.7
Correl.			0.68		0.64

*FDI, field disease incidence; RsW, *Ralstonia solanacearum;* correl., correlation coefficient factor. Mean percentage of field disease incidence correlated with its corresponding mean percentage of *R. solanacearum* infected symptomatic and *R. solanacearum* infected non-symptomatic samples

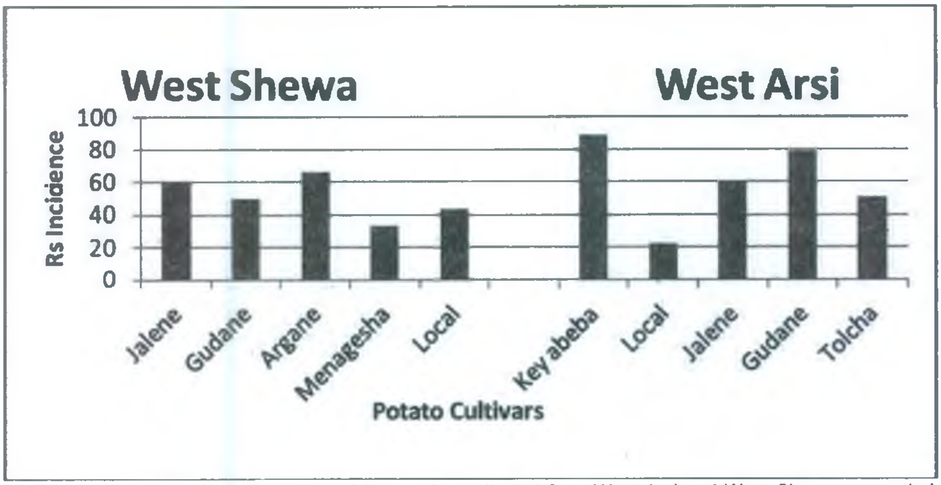


Figure 4. Incidence of BW in potato cultivars tested in samples collected from West Arsi and West Shewa zones during short rainy season, 2012. Local, locally maintained potato variety used by the farmers

Discussion and Conclusion

As potato cultivation is highly increasing in Ethiopia, problems associated with bacterial wilt disease should be addressed properly. The aims of this survey were to assess the current BW incidence in the farmers' potato fields using plant disease symptoms and serological techniques, and also to determine the possibility of using stems instead of tubers in testing for *R. solanacearum* infections. Similar to our field observations, Bekele *et al.* (2011); Kwambai *et al.* (2011); Lemessa and Zeller (2007) and Mwangi *et al.* (2008) reported generalized wilting of the potato plant, milky oozes from potato eyes, browning of vascular rings and necrotic potato tubers in BW suspected potato fields. Thus, the results obtained from our current field observations and laboratory tests showed that bacterial wilt is one of the limiting factors of seed and ware potato productions in the surveyed potato fields. In many of the visited fields (Viz., Shashemene, Arsi-Negele, Holetta and some experimental plots) local potato varieties were less symptomatic and less prone to infection as compared to the improved potato cultivars. This can be explained by the fact that continuous breeding to increase productivity might have resulted in loss of pathogen resistant traits and/or adaptation of local varieties to pathogens over time. Plant breeding, with many advanced agricultural technologies, has made remarkable progress in increasing crop yields for over a century. However, continuous inbreeding and selective breeding of particular genes has the risk of losing some of the other genes from the gene pool altogether that could increase susceptibility of plant to specific pathogens (Evans, 1997). In relation to this, further research should be conducted to determine susceptibility of improved potato cultivars to *R. solanacearum* in a control environment with identical *R. solanacearum* isolates.

There was a significant difference ($p \leq 0.05$) of bacterial wilt incidence between the two administrative zones, with West Arsi zone (67 %) giving a higher disease incidence compared to West Shewa zone (51 %) (Fig. 3 A). It also varied between study areas and even among fields within a study area. The highest disease incidence was recorded at Shashamene (73 %), and the lowest in fields sampled at Wonchi and Tikur-Inchini (20 % each). Kwambai and co-workers (2011) reported that the BW incidence was higher in the north Rift Valley region of Kenya, and the disease occurrence was less than comparable study conducted in Northern Ethiopia (Bekele *et al.*, 2011). The disease incidence was significantly different ($p \leq 0.05$) among surveyed fields and had negative correlations (r = -0.61) with altitudes indicating that the disease is more common in lower altitudes (with warmer and humid climate) than higher altitudes. Bacterial wilt incidence caused by *R. solanacearum* is high in warmer areas, moderate in mild altitude areas and low in cool regions (Ciampi *et al.*, 1980 and Hayward, 1991). With respect to altitude, the survey result was in harmony with the findings of Ateka *et al.*, (2001) and Kwambai *et al.*,(2011). As reported by several authors (Ajanga, 1993; Janse, 1996 and Nyangeri *et al.*, 1984), factors such as temperature, rainfall, altitude, soil pH and moisture, root knot nematodes, potato cultivars and cropping systems could account for such disparities. The influences of these factors are, however, suggested to be addressed by other independent studies.

In both administrative zones, farmers grow potato at least twice a year in the same field and rarely rotate with tomato, cabbage, pepper, onion and maize. They assume that wilting is caused by nematodes and remove wilted plant and dispose it in the same potato field. Thus, the high bacterial wilt incidence in Shashamene, Kofele, Arsi-Negele, Guder, Holetta, Ambo and Adea-Berga areas could be attributed to contaminated soils due to the continuous potato cultivation of the same land over time, inadequate crop rotation intervals with non host crops, use of uncertified seed tubers and poor or absence of bacterial wilt management practices. Recycling of infected potato seed and building up of the pathogen (*R. solanacearum*) in the soil over time contributed to the spread of BW disease (Biniam and Tadesse, 2008 and Kwambai *et al.*, 2011). Nyangeri *et al.* (1984) also reported that latently infected seed tubers are potential sources of inoculum of *R. solanacearum* leading to disease epidemic and pathogen spread from place to place and from season to season. Wonchi and Tikur-Inchini had less and equal level of bacterial wilt incidence, possibly due to their location in similar agro-ecology. It is also possible to suggest that samples at both locations were collected from seed potato production fields, the seeds were believed to be obtained from known sources (Research Stations) and hence were likely to be free of *R. solanacearum*. Ware potato growers maintain maximum production potential over the seasons by replacing their seed potato stock or with high quality seed potato from seed potato growers (Struik and Wiersema 1999).

Overall, there was a high BW incidence indicating that BW is widely spread to most potato growing areas in Ethiopia. As reported by Priou *et al.* (1999) it has been a serious potato production constraint in African countries including Uganda, Ethiopia, Kenya, Madagascar, Rwanda, Burundi, Nigeria and Cameroon.

From the study on possibility of using stem instead of tubers for detection of *R. solanacearum*, there were samples of both *R. solanacearum* positive in stems and tubers, *R. solanacearum* positive only stems, *R. solanacearum* positive only tubers, and those *R. solanacearum* negative in both stems and tubers. Both *R. solanacearum* infected stems and tubers and both *R. solanacearum* negative stems and tubers were negatively correlated (r = -0.8). The mean percentage of both *R. solanacearum* infected and *R. solanacearum* free stems and tubers were significantly different (Table 3). These observations showed that an infected plant can have healthy tubers and infected stems or infected tubers and healthy stems. The survey result has also shown comparable *R. solanacearum* infection of the tuber and the stem samples, indicating the potential of using stem instead of a tuber, as tuber sampling has economic implications. Bekele *et al.*, (2011) and Mwangi *et al.*, (2008) also reported positive correlations of stem and tuber tests for *R. solanacearum* infections. With regard to this study, further researchs should to be done to find out the source of inoculums, *R. solanacearum* favoring cellular environment (tuber/stem cell saps) and biotic and abiotic stresses.

Table 3. Percentage of *R. solanacearum* status in samples collected from West Shewa and West Arsi zones, and bacterial wilt correlation between tuber and stem samples*

Study areas	Positive in stems only	Positive in tubers only	Positive both in tubers and stems	Negative both in tubers and stems
Guder	8.6	5.7	68.6	17.1
Holetta	4.3	13	65.2	17.4
Wonchi	10	20	20.0	50.0
Tikur-Enchini	0.0	0.0	20.0	80.0
Ambo	14	20	66.7	4.20
Jibat	10	6.9	55.2	27.6
Dendi	9.6	15	43.6	31.9
ELifeta	11	6.8	54.5	27.3
Adea Barga	7.7	0.0	61.5	30.8
Jeldu	24	8.0	52.0	16.0
Kofele	6.7	6.7	60.0	26.7
Shashamene	0.0	0.0	73.3	26.7
Arsi-Negele	0.0	6.7	66.7	26.7
Correl.	0.4		-0.8	-
LSD	0.9		0.0	

*Correl., correlation coefficient factor; LSD, least significant differences

Subsequently, in addition to generating baseline information on BW economic importance, geographic distribution of the pathogen and vulnerable potato cultivars to *R. solanacearum*; it is of practical significance to inform and make farmers aware and practice on a range of available disease management alternatives, with due emphasis on affordable disease management options. It is also hereby suggested that the occurrence of bacterial wilt disease in a field should be considered as one of the major parameters in the national potato improvement program to avoid the release and distribution of susceptible varieties to farmers. Planting healthy seed tubers (that are certified through a recognized seed potato inspection program) and internal quarantine are recommended to be implemented to effectively reduce the spread of the pathogen. Moreover, the crop lost due to bacterial wilt should be quantified across the surveyed areas with independent studies so as to ascertain the magnitude of the problem.

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