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Distribution and Relative Importance of Hot Pepper *Fusarium* Wilt (*Fusarium oxysporium* f.sp. capsici) and Associated Agronomic Factors in the Central Rift Valley of Ethiopia

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Abstract

Hot pepper (*Capsicum annum* L.) is one of the important cash crops to Ethiopian smallholder farmers and an important agricultural commodity which contribute to export earnings. *Fusarium* wilt caused by *Fusarium oxysporium* f.sp. capsici (FOC) is one of the major pathogen that constrained production and productivity of hot pepper in Ethiopia. The present study was conducted to assess the distribution of *Fusarium* wilt and associated factors in one of the major hot pepper production regions in Ethiopia, the Central Rift Valley. Assessment of *Fusarium* wilt incidence and associated agronomic factors was carried out in six districts during the 2018 main cropping season. The survey results revealed varying distribution and intensity of *Fusarium* wilt, with 15.1, 30.9, 40.0, 42.9, 46.0 and 46.5% wilt incidence in Adami Tullu Jiddo Kombolcha, Dugda, Adama, Meskan, Alaba and Mareko districts, respectively. These variations in percentage wilt incidence were mainly associated with agronomic practices. More importantly, seed source and method of seedling propagation were the most important agronomic practices that might contribute for variations in disease intensity. It was observed that *Fusarium* wilt incidence is higher in districts that mostly used seeds purchased from local market and raise seedlings on a seedbed compared to those who used seedlings produced from farmers' saved seeds in a seedling tray. Since it was not possible to obtain a comprehensive data on the type of cropping system, it is very difficult to conclude on the role of cropping systems on the distribution and intensity of *fusarium* wilt in the present study area. It was also observed that, Foc can infect hot pepper at seedling, vegetative, flowering and harvest growth stage.

Keywords: Hot pepper; *Fusarium* wilt; Distribution; Agronomic factors

Introduction

Hot pepper is one of the important cash crops to Ethiopian smallholder farmers and an important agricultural commodity which contributes to export earnings. It is rich source of vitamin A, E and contains five to six times as much vitamin C as an orange or a lemon, making it an ideal vegetable to prevent flu colds more than any other vegetable crop [1]. The average daily consumption of hot pepper by an Ethiopian adult is estimated to be 15 g which is higher than tomatoes and most other vegetables [2]. According to FAOSTAT, a world average yield of 32.3 t/ha green and 3.8 t/ha dry pepper have been reported [3]. In Ethiopia, average dry and green hot pepper production during the 2014 production year was 1.6 t/ha and 10.7 t/ha, respectively, which is far below the world's average [4]. Interestingly, hot pepper covers 73.1% of all the area under vegetables in Ethiopia [5].

Despite the aforementioned significant economic and health values, hot pepper production in Ethiopia has been declining due to several factors including the use of poor varieties, poor cultural practices and the increasing prevalence of fungal, bacterial and viral diseases [6]. In particular, the disease factors are responsible to drastically reduce the yield potential and quality of hot pepper [7,8].

Wilt disease caused by *Fusarium oxysporium* are becoming the leading problems of pepper producing countries of the world including Ethiopia. Recently, Assefa et al. reported that, 86.4% wilt incidence caused by *fusarium* wilt in Bako areas, Ethiopia [9]. More importantly, a study on yield loss assessment due to *fusarium* wilt in one of the major growing areas of Ethiopia revealed a high yield loss ranging between 68% and 71% [10]. Another study on assessment of hot pepper diseases in South Nation, Nationalities and Peoples Region (SNNPR) of Ethiopia by Shiferaw and Alemayehu showed the occurrence of 30%-55% *fusarium* wilt incidence and confirmed *fusarium* wilt as the leading fungal disease of pepper in the area [11]. Therefore, this paper presents the distribution of hot pepper *fusarium* wilt and associated agronomic factors in the Central Rift valley of Ethiopia. The results of this study will be used for the development of integrated *fusarium* wilt management and identify associated agronomic factors in the central rift valley of Ethiopia.

Materials and Methods

Description of study area

A field survey was conducted during the 2018 main cropping season to assess the spatial distribution and relative importance of *fusarium* wilt in six pepper growing districts in the Central Rift Valley of Ethiopia. The surveyed districts were Alaba, Dugda, Mareko, Meskan, Adama and Adami Tullu Jiddo Kombolacha (Figure 1). From each

district, 3 Farmers association were selected based on their potential for hot pepper production. Similarly, from each Farmers association, 5 farmer's fields were selected based on the potential of pepper production.

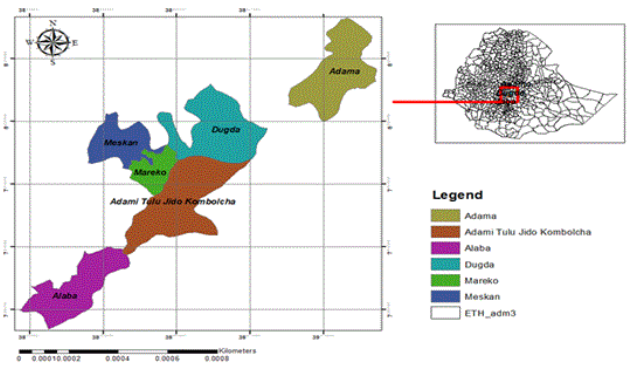

Figure 1: Map showing specific study districts in the Central Rift valley of Ethiopia.

Assessment of hot pepper *fusarium* wilt in the field

Fusarium wilt incidence at each farmer's field were assessed through direct visual observation of the typical FOC symptoms (slight vein clearing, leaf drooping, slight yellowing of lower leaves, browning of the vascular tissue and complete plant death). These assessments were made along the two diagonals (in an "X" fashion) using 1 m^2 quadrants at approximately 20-50 m far apart from each other. In each field, 5 quadrants were systematically assigned to the respective points. From each point within a quadrant, *fusarium* wilt incidence was calculated by counting the number of healthy and diseased plants and expressed as a percentage of the total number of plants assessed [12]. From 10 days old cultures, conidia were harvested to 15 ml beaker by adding 10 ml of sterile distilled water (SDW) in each Petri plate. From the filtered culture, conidia were re suspended in SDW and the final conidial density was adjusted to 1×10^6 spore/ml using a haemocytometer.

Effect of agronomic factors on hot pepper *fusarium* wilt intensity

In order to see the effect of agronomic practices on the distribution and intensity of *fusarium* wilt, data on seed source, cropping system, method of seedling production, and crop growth stage at the time of disease assessment were collected from each field using predesigned questionnaire.

Results and Discussion

Spatial distribution and relative importance of hot pepper *fusarium* wilt

Disease survey conducted in six districts in the Central Rift valley of Ethiopia during the 2018 main cropping season revealed that hot pepper *fusarium* wilt (HPFW) was widespread in the study areas with different magnitude as shown in color variation (Figure 2).

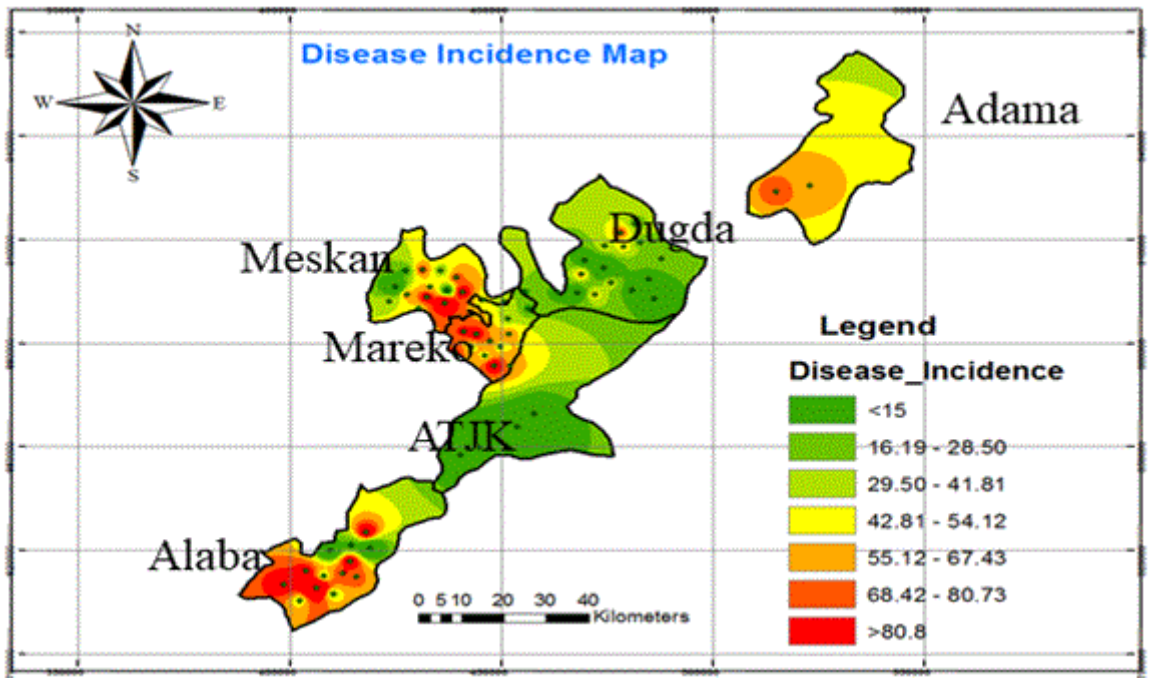

Figure 2: Map showing spatial distribution of hot pepper *fusarium* wilt incidence across six districts in the Central Rift Valley of Ethiopia during the 2018 main cropping season. ATJK: Adami Tullu Jiddo Kombolcha.

The highest disease incidence (red color) was observed frequently in Alaba (>54% and above), followed by Meskan and Mareko districts. In Adami tullu Jiddo Kombolcha and Dugda districts, shown predominantly in green, there was relatively lower HPFW incidence

ranging between 0% to 42%. Intermediate levels of HPFW incidence (43%-54%) were mainly recorded in some fields of Alaba, Mareko, Meskan and Adama districts.

Results of mean HPFW at district level revealed 46.5% in Mareko, 46.0% in Alaba, 42.9% in Meskan, 40.0% in Adama, 30.9% in Dugda and 15.1% in Admi Tullu Jiddo Kombolcha districts (Table 1). When we look at disease intensity at kebele levels, the highest (90.5%) incidence was recorded at Ansha-2 kebele which is located in Alaba district followed by Bate Futo kebele of the Meskan district (79.41%). In contrast, the lowest HPFW incidence was recorded at Eddo Gojola-5 (2%) and Alam Tena (2.9%) kebeles of Adami Tullu Jiddo Kombolcha and Alaba districts, respectively. In Adami tullu Jiddo Kombolcha and Dugda districts, farmers were using hybrid seed which is obtained from different company and Farmers in these districts have relatively more aware of improved technologies related to hot pepper production methods.

On the other hand, mean disease incidence in Adama, Alaba, Meskan and Mareko districts were relatively higher. This could be due to the presence of favorable edaphic and climatic factors coupled with the traditional farmer's practices. One possible reason could be the practice of continuous cropping, growing the crop within the same field for several years. In this regard, accumulation of inoculum source will increase with increasing the production of hot pepper within specific site.

Few years ago, Shiferaw and Alemayehu reported that 10%, 7.5% and 32.5% of pepper *fusarium* wilt incidence in Mareko, Meskan and Alaba districts, respectively. In this regard, the higher disease levels reported in the present study indicates that the intensity of HPFW in these areas is progressing over time. If there is high *Fusarium* wilt epidemic, it accounts for yield losses of up to 80% in the CRVE [13]. In Assosa and Kamashi Zones *Fusarium* wilt caused by *F. oxysporum* is the major important disease which causes up to 50% wilt incidence [14].

District	NF	PA	Mean FWI/PA (%)	Mean FWI/Dst (%)
Alaba	13	Ansha-2	57.7	46
		Ansha-1	53.5	
		Alam tena	26.9	
		Bate Futo	43.9	
Meskan	14	Samen Dida	45.8	42.9
		Bache Gulchan	38.9	
		Dida Midore	53.1	
Merako	15	Dida Halibo	52.5	46.5
		Jara Damako	33.9	
ATJK	5	Eddo Gojola	15.1	15.1
		Bekkele Girrisa	31.5	
Dugda	16	Dodota Dembal	21.2	30.9
		Giraba Korke Adi	40.1	
		Wonji	42.5	
Adama	7	Wake Tiyo	29	40
		Melkassa	48.5	
Total	70	SD	12.5	12.1
		Mean	39.6	36.9
		CV	0.3	0.3

Abbreviations: NF: Number of Field; FW: *Fusarium* Wilt incidence; PA: Peasant Association; SD: Standard Deviation; CV: Coefficient of Variation; Dst: District

Table 1: Hot pepper *fusarium* wilt incidence in different districts and Peasant association of the Central Rift Valley of Ethiopia during the 2018 main cropping season.

Regarding the variation of HPFW within and across districts, relatively higher incidence [maximum ≥ 50%; 90.5% (Alaba), 79.4% (Meskan), 63.6% (Mareko), 50% (Dugda) and 50% (Adama)] has been recorded in all districts of the study area except Adami Tullu Jiddo Kombolcha districts which had a maximum HPFW incidence of 19.4%. Regarding the minimum HPFW incidence, there was no striking variation among districts, 2.98% (Alaba), 15% (Meskan), 26% (Mareko), 2% (Adami Tullu Jiddo Kombolcha), 18% (Dugda) and 19% (Adama) (Table 2).

District	Maximum FWI (%)	Minimum FWI (%)	Range (%)
Adama	50.0 (Melkassa)	19.0 (wake Tiyo)	31
Alaba	90.5 (Ansha 2)	2.9 (Alem Tena)	87.6
ATJK	19.4 (Eddo Gojola)	2.0 (Eddo Gojola)	17.4
Dugda	50.0 (Graba Korke Adi)	18.0 (Bekele Girrisa)	32
Mareko	63.6 (Dida Midore)	26.0 (Jarra Damaka)	37.6
Meskan	79.4 (Bate Futo)	15.2 (Samen Dida)	64.4

Note: Name of Peasant association with maximum and minimum disease incidence is indicated in brackets.

FWI: Fusarium wilt incidence; ATJK: Adami tullu Jiddo Kombolcha

Table 2: Maximum and minimum hot pepper *fusarium* wilt incidence across and within six districts in the Central Rift valley of Ethiopia, 2018.

Assefa et al. reported 86.4% pepper wilt incidence due to *F. oxysporium* in Ethiopia indicating the variation among wilt causing pathogens in different localities of Ethiopia [15]. From the present survey, it was understood that farmers call the pathogen in Amharic language 'Adiriq' which means that it causes dry, this is the major description of the causal agent. In Alaba for example, at seedling stage complete devastation was observed and farmers were forced to replace that field with teff production, which is economically high loss.

Effect of agronomic practices on *fusarium* wilt incidence

In order to see the effect of agronomic practices on the distribution and intensity of *fusarium* wilt data on seed source, cropping system, method of seedling production, and crop growth stage at the time of disease assessment were collected from each field. In the present study area, farmers obtain pepper seed from different sources i.e. from own (farmers') source, NGO and local market. Among the interviewed

farmers in Alaba district, 77% use their own seed stored from previous season and the remaining 23% obtain/buy seeds from the local market. In this district, a HPFW incidence of 35.8% and 44.7% was recorded in farmers' fields, which used own and market seeds, respectively. In Meskan district, 69% and 31% of the farmers obtain the seed from own source and local market with HPFW incidence of 38.4% and 53.9%, respectively. A similar trend has been observed in Mareko district where 80%, 13% and 7% of farmers obtain their seed from own source, Non-governmental organization and local market, respectively. The respective HPFW incidence in this district was 45.8, 51.0 and 45.9%. A similar trend has been observed in the remaining districts.

Besides the seed source, the method of seedling production has an impact on managing wilt causing pathogens such as FOC. In the present study it was observed that the method of seedling propagation varies in different districts. In Alaba, Meskan, Mareko and Adama districts for example, all the interviewed farmers (100%) produce pepper seedlings on a seedbed. In Dugda 73.3% and 26.6% of interviewed farmers produce seedlings on seed tray and seedbed, respectively. It is interesting that in these district farmers already adopt the use of seed tray for the production of seedling and mean HPFW incidence was relatively lower wilt incidence (29.6%) was recorded in fields where seedlings produced on a seed tray has been transplanted compared to those which used seedlings produced on a seedbed (i.e. 34.1% wilt incidence). Similarly, in Adami Tullu Jiddo Kombolcha district relatively lower wilt incidence (12.3%) has been recorded in farmers' fields where seedlings were produced on a seed tray compared to those who used seedbed (i.e. 19.2% wilt incidence) (Table 3). In general it was observed that disease incidence was higher in districts which used seedbed produced seedlings. In most assessed districts, seedbed was prepared on open fields with little care and this might lead to high chance of infection at the early stages of plant growth and results in higher wilt incidences. Nevertheless, this needs further investigation to find out whether this factor has significant contribution on the intensity and transmission *fusarium* wilt in hot pepper.

Regarding cropping system, it is known that, intercropping or crop rotation has an impact on reducing sporulation and spread of *fusarium* wilt [16]. In the present study, there is no comprehensive information was not obtained from all districts and it is much difficult to comment on the impact of cropping system on disease intensity. Nevertheless, since FOC is hot pepper specific pathogen which infects only hot pepper, the role of intercropping and/or crop rotation in managing this disease should not be ignored. *Fusarium* wilt of hot pepper occurs at any growth stage i.e. starting from seedling to the harvest time [17]. From the present data, it was observed that there is no specific growth stage when *fusarium* infection occurs differently both in terms of presence and intensity.

Agronomic practices		Percent Fusarium wilt incidence (FWI) in different districts											
Practice	Variables	Adama		Alaba		ATJK		Dugda		Meskan		Mareko	
-		N (%)	FWI	N (%)	FWI	N (%)	FWI	N (%)	FWI	N (%)	FWI	N (%)	FWI
Seed Source	Farmer	50	35.3	77	45.4	0	ND	13	38.5	69	38	80	46
	Market	50	44.7	23	47.9	100	15.1	47	32.8	31	54	6.6	46
	NGO	0	ND	0	ND	0	ND	40	25.9	0	ND	13	51
Seedling Production Cropping System	Seed bed	100	40	100	46	40	19.2	27	34.1	100	43	100	47
	Seed tray	0	ND	0	ND	60	12.3	73	29.6	0	ND	0	ND
	Mono cropping	100	40	100	46	100	15.1	100	30.9	69	43	53	48
	Intercropping	0	ND	0	ND	0	ND	0	ND	31	43	47	45
Growth	Vegetative	0	ND	77	48.3	0	ND	6.6	16	0	ND	0	ND
	Flowering	25	29	23	38.4	40	10.5	0	ND	15	53	6.7	26
Stage	Pod setting	75	46	0	ND	40	18	33	30	15	39	6.7	28
	Harvest	0	ND	0	ND	20	18	60	32.8	69	42	87	50
	Abbreviations: NGO: Non-Governmental Organization; N: Number Of Respondents in percent; ND: No Data												

Table 3: Summary of farmers' agronomic practices and hot pepper *fusarium* wilt incidence in the Central Rift valley of Ethiopia during the 2018 cropping season.

Confirmation of *Fusarium oxysporium* isolates via pathogenicity test

The pathogenicity and/or virulence level isolates identified as FOC by colony and microscopic characteristics were evaluated to support the survey result. To confirm the pathogenic level of identified isolate from survey, susceptible variety Mareko Fana were infected and grown under greenhouse conditions [18]. To further verify that disease symptoms are due to pathogen infections, the pathogen was re-isolated from the diseased plants on PDA medium and its colony and microscopic features were compared with descriptors [19]. Interestingly, Dugda district (Giraba Korke Adi kebele), was found as the major source of the most pathogenic isolate in pathogenicity that

induced 100% disease incidence. For this reason, isolate 4DGK was identified as a master isolate for further pathological studies (Figure 3).

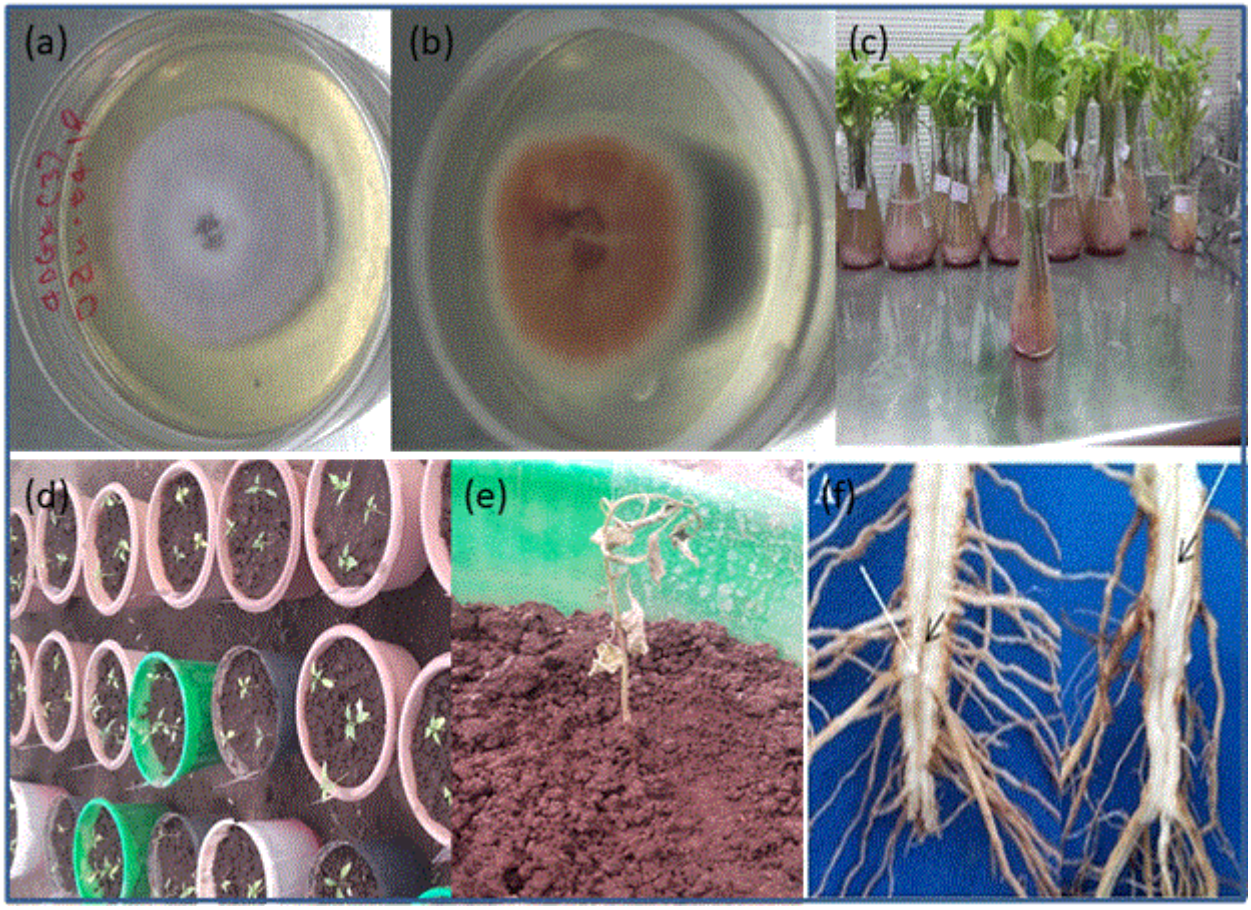

Figure 3: Pathogenicity test (picture taken sixty days after inoculation); 4DGK *fusarium* isolate (a and b); root dipping technique and transplanting (c and d); seedling death and vascular discoloration (e and f).

Summary and Conclusion

Hot pepper production is affected by many biotic and abiotic factors and among the biotic factors diseases has been identified as a major limiting factor. Among various diseases of hot pepper which caused by fungi, bacteria and viruses; *fusarium* wilt caused by *Fusarium oxysporum* f.sp. capsici is the most common and causes qualitative and yield damages. The present study was undertaken in order to assess the distribution and relative importance of *fusarium* wilt of hot pepper and associated agronomic factors affecting disease intensity in the central Rift Valley of Ethiopia.

In summary, distribution and intensity of *Fusarium* wilt, with 15.1, 30.9, 40.0, 42.9, 46.0 and 46.5% wilt incidence in Adami Tullu Jiddo Kombolcha, Dugda, Adama, Meskan, Alaba and Mareko districts, respectively. The highest wilt incidence was recorded in Alaba (90.5%) district and lowest wilt incidence were recorded in Adami Tullu Jiddo Kombolcha (2%) district. The variation of wilt incidence might be associated with several agronomic practices such as the source of planting material (seed), the type of cropping system practiced in the area and method of seedling production.

Three sources of planting material (seed) were identified in this study, farmers' own seed, NGO and local market. In most cases, farmers obtain pepper seed from local market or use their own seed stored from previous harvests. In rare cases, non-governmental organization provides the seed for some model farmers in Dugda district. In Alaba, Meskan, Mareko and Adama, farmers raise seedling on a seedbed. Whereas most farmer's in Dugda and Adami Tullu Jiddo Kombolcha districts produce seedlings on a seed tray. Disease incidence was higher in districts that practice the production of seedlings on a seedbed and compared to those who use seed tray. In conclusion, the present study showed that *fusarium* wilt of hot pepper is becoming an important treat in the production of hot pepper in the central rift valley of Ethiopia. It was also found that several factors related to pathogen characteristics and agronomic/cultural practices might positively or negatively influence the intensity of the disease in the study area.

Introduction of hot pepper seed should pass through quarantine system and Basic studies on molecular identification should have to be conducted to characterize identified isolates in Ethiopia. Varietal screening should be intensively conducted to replace susceptible one

and integrated *fusarium* wilt management tactics is important for sustainability.

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References

1. Bosland PW, Votava EJ (2000) Peppers, Vegetables and Spices Capsicum. CABI Publi New York, pp: 181-198.
2. Melkassa Agricultural Research Center (2004) Progress Report Addis Ababa. Miller JJ.1946. Taxonomy Fusarium with particular reference to section Elegans.
3. FAOSTAT (2017) FAO Statistics Division.
4. Alemu A, Wodajo A, Chuntal K (2016) Performance Evaluation of Elite Hot Pepper (Capsicum Annum) Varieties for Yield and Yield Components at Derashea, South-Eastern Ethiopia. Int J Res Granthaalayah 4: 95-100.
5. Central Statistical Agency Agricultural Sample Survey (2018) The Federal Democratic Republic of Ethiopia, Meher Season.
6. Fekadu M, Dandena G (2006) Status of Vegetable Crops in Ethiopia. Ugandan J Agri 12: 26-30.
7. Ochoa NA, Ramirez MR (2001) In vitro chilli pepper biotechnology. In vitro Cellular and Developmental Biology-Plant 37: 701-729.
8. Egea C, Dickinson MJ, Candela M, Candela ME (2002) B-1, 3-glucanase iso enzyme and genes in resistant and susceptible pepper (C. annuum) cultivars infected with Phytophthora capsici. Physiol Planta 107: 312-318.
9. Assefa M, Dawit W, Lencho A, Hunduma T (2015) Assessment of Wilt Intensity and Identification of Causal Fungal and Bacterial Pathogens on Hot Pepper (Capsicum Annuum L.) in Bako Tibbe and Nonno Districts of West Shewa Zone, Ethiopia. Int J Phytopathol 4.
10. Soboka TB, Fininsa C, Gorfu D (2012) Integrated Approach and Plant Extract Management Options against Pepper Wilt (Fusarium Oxysporum Var. Vasinfectum) at Bako, Western Ethiopia.
11. Mekonen S, Chala A (2014) Assessment of Hot Pepper (Capsicum species) Diseases in Southern Ethiopia. Int J Sci Res 3: 91-95.
12. Mehrotra RS, Aggarwal A (2003) Plant pathology (2nd edn) Tata McGraw-Hill publishing company limited, New Delhi. pp: 822-825.
13. Shimeles A, Berhanu B, Bekele K (2007) Survey Report on Current Pepper Production Constraints in Major Pepper Growing Areas of Ethiopia.
14. Kebede M, Gidesa A (2017) Survey and Identification of Diseases on Major Crops of Assosa and Kamashi Zones, Ethiopia. Galore Int J Appli Sci 1: 27-31.
15. Assefa M, Dawit W, Lencho A, Hunduma T (2015) Assessment of wilt intensity and identification of causal fungal and bacterial pathogens on hot pepper (capsicum annuuml.) In Bako Tibbe and Nonno districts of West Shewa Zone, Ethiopia. Int J Phytopathol 4: 21-28.
16. Marburger DA, Venkateshwaran M, Conley SP, Esker PD, Lauer JG, et al. (2014) Crop Rotation and Management Effect on Fusarium spp. Populations. Crop Sci 55: 1-12.
17. Agrios GN (2005) Plant Pathology (5th edn) Burlington, USA. Els Acad Pre.
18. Sadessa K, Hunduma T, Assefa M (2016) Characterization and Evaluation of Hot Pepper (Capsicum annuum L.) Cultivars against Bacterial Wilt Disease (Ralstonia solanacearum), Pyrex J Microbiol Biotechnol Res 2: 22-29.
19. Leslie JF, Summerell BA (2006) The Fusarium Laboratory Manual. Black Well Publishing.