

Research Article

Survey of Major Hot Pepper (*Capsicum annum* L.) Diseases in Ilu Aba Bor and Jima Zones of Southwestern Oromia, Ethiopia

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Abstract

In the current study, disease survey was initiated to determine the relative occurrence, distribution and status of major hot pepper diseases in Jima and Ilu Aba Bor zones. Prevalence, incidence and severity of major hot pepper diseases were assessed and quantified. The survey was conducted in six districts of Jima and Ilu Aba Bor zones, covering 18 Kebeles and 54 fields. Kebeles were randomly selected from each district based on their representativeness of hot pepper production. The disease assessment was made along the two diagonals (in an “X” pattern) of the field from five points using 1 m × 1 m (1 m²) quadrates. The assessment was done for disease prevalence, incidence and severity. Cercospora leaf spot (*Cercospora capsica*), Damping off, Bacterial leaf blight and viral diseases were the Major Hot pepper seedling diseases in both Jima and Ilu Aba Bora Zones. The prevalence of *Cercospora* leaf spot (*Cercospora capsica*) was the highest hot pepper plant disease recorded in Jima and Ilu Aba Bora areas, with a prevalence of 100% and a high level of incidence and severity. The main diseases that infected peppers after transplanting in the inspected area were *Cercospora* leaf spot (*Cercospora capsici*), Blossom end rot (*Alternaria* spp.), Fusarium wilt (*Fusarium oxysporum*), Anthracnose (*Colletotrichum gloeosporioides*) and Bacterial leaf blight in Jima and Ilu Aba Bora Zones. The importance of each disease was determined by calculating the prevalence, incidence and severity values. The current study shows that hot pepper production is currently limited by several diseases and indicates the need of research on designing management strategies and options for the major diseases.

Keywords

Incidence, Severity, Distribution, Disease, Hot Pepper

1. Introduction

Hot pepper (*Capsicum annum* L.) is an important crop globally grown as vegetable and spice [4]. This crop is native to Latin America and belongs to the family Solanaceae [24]. Portuguese had introduced hot pepper to Ethiopia in early 17th century [12]. In Ethiopia, the production history and use of pepper is perhaps more ancient than the history of any

other vegetable crop except tomato [9]. Hot pepper is the most important vegetable, which can be found on the daily dish of every Ethiopians [23]. According to [6], in Ethiopia hot pepper (*Capsicum annum*) is an economically and traditionally vital crop, and for most Ethiopians food is tasteless without hot pepper. The fine powdered pungent product is an

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important flavoring and coloring component in the common traditional sauce “Wot”, (stew). In addition to dietary benefits, capsicums are also high value crops in both domestic and export markets. Since it is an industrial Crop, it generates employment to urban and rural workers. The deep red colored cultivars have a very high processing demand in the country [7]. In spite of its dietary and economic benefits, Capsicum productivity in Ethiopia is far below the world average that strongly demands immediate productivity improvement interventions. People consume pepper for intake enhancement as well as to supplement the dietary needs. It is also one of the major income generating crops for most households of the pepper producing areas and plays a vital role in food security in Ethiopia [25]. Despite the importance of hot pepper in Ethiopia, total crop failure due to diseases has been common and sometimes farmers are forced to abandon their production due to excessive disease pressure in the field [29]. Among hot pepper diseases, Powdery mildew, Leaf blight, Wilt and Pepper mottle virus [16, 2, 15] have been reported in Ethiopia. Recently, wilt causing pathogens are becoming the leading problems reported by causing 86.4% wilt incidence due to Fusarium wilt in Ethiopia [1]. The virus has caused losses of 60–100% of marketable fruit, while pepper anthracnose has caused losses of up to 100% [18]. Bacterial spot caused by a bacterial seed pathogen (*Xanthomonas campestris* pv. *vesicatoria*) is also capable of causing severe defoliation of plants, leading to reduced yield and loss of quality of the harvested fruit when severe damage occurs in developing fruit [28]. Although the study areas have great potential in terms of physical environment and business opportunities, hot pepper production and productivity have declined due to diseases. Therefore, this activity was initiated to determine the relative occurrence, distribution and status of hot pepper diseases in the study area.

2. Materials and Methods

2.1. Description of Study Area

The field survey was conducted in a part of the southwestern areas of Oromia - Jima and Ilu Aba Bor during the main growing season 2021-2022. The disease assessment survey was conducted in three districts of Jima area and Ilu Aba Bor area (Table 1). The disease survey was conducted to assess the prevalence, incidence and severity of major hot pepper diseases. The geographical locations of the study areas were within an altitude range of 1500 m.a.s.l. to 2530 m.a.s.l. respectively.

2.2. Field Survey

Hot pepper disease survey was conducted in six districts of two zones during the main season of 2021 to 2022. The survey was conducted in 18 Kebeles and 54 fields. Random sampling technique was employed for the survey. The

kebeles were randomly selected from each district based on the representation of the area's hot pepper production. The locations were at least 3-5 km apart and the distance of the locations depended on the topography and the relative importance of the crop within each location. The disease assessment was made along the two diagonals (in an “X” pattern) of the field from five points using 1 m × 1 m (1 m²) quadrates. Questionnaire was developed to interview farmers on some field-related and other issues. Hot pepper management practices such as variety grown (local or improved), previous crop (cereals, pulses or vegetables), date of planting (sowing), crop density, height, weed density per square meter, type and rate of fertilizer, soil type, growth stage, type of disease observed and fungicide used, were collected and recorded. In each field, plants in the quadrats were counted and separated into healthy and diseased plants.

3. Results and Discussions

3.1. Characteristic Features of Agronomic Cultural Practices and Major Hot Pepper Seedling Diseases Severity

According to the survey results, *Cercospora* leaf spot (*Cercospora capsica*), Damping off, Bacterial leaf blight and viral diseases were the Major Hot pepper seedling diseases in both Jima and Ilu Aba Bora Zones. The disease severity of hot pepper seedlings CLS was worst in low land altitude (100%) followed by Midland altitude (93.8%) of Jima zone (Table 1). All recorded hot pepper seedling diseases severities in the Ilu Aba Bor zone were in lowland altitudes (1500-1950) (Table 1). In this lowland altitude, CLS (100%) was the highest among the hot pepper seedling diseases severity recorded in both zones followed by Damping off (76%) in Ilu Aba Bor zone (Table 1). The maximum hot pepper seedling severity of *Cercospora* Leaf spot (93.8%) and Damping off (18.2%) were recorded in Mid-land altitudes (1951-2530) of Jima Zone. This results in line with [1]. In Ethiopia, pepper grows in warm, humid climates and best fruit is obtained at temperatures of 21 to 27 °C during the day and 15 to 20 °C at night [13]. It is widely cultivated in most parts of the country, with the main production areas concentrated at an altitude of 1100–1800 m above sea level [21].

Regarding to the use of hot pepper seeds 24(85.7%) and 18(69%) use from local market in Jima and Ilu Aba Bor zones respectively. Only 4(14.3%) and 8(31%) farmers were used hot pepper seeds from own seed extraction in Jima and Ilu Aba Bor zones respectively. For this reason the Hot pepper disease severity of CLS (59.3%) and Damping off (29.6%) diseases were worse on most seeds used from local market in Jima zone and CLS (60%) and Damping off (48%) diseases were worse on most seeds used from local market in Ilu Aba Bor zone. Farmers use to grow mostly local selections, because there were shortages of improved varieties.

Seeds were either from former harvests or bought from local markets. Such seed lots were often mixtures of different varieties with impurities harboring pathogens. Local variety was the most susceptible to disease attack and even symptom development started at seedling stage in the nursery. Among the six surveyed districts, red pepper disease severity were highly recorded where the farmers cultivated local red pepper than red pepper improved varieties [19]. According to [27], out of 90 seed beds assessed in south Ethiopia, 55% of seed beds were infected by seedling diseases.

In all surveyed areas most of farmers were sown seedlings on flat seedbed types. Out of 28 farmers' fields assessed 26(93%) were sown seedlings on flat seedbeds in Jima zone. Similarly, Out of 26 farmers' fields assessed 21(81%) were sown seedlings on flat seedbeds in Ilu Aba Bor zone. Accordingly most hot pepper seedling disease severity was caused damage hot pepper seeds were sown on flat seedbed types in both Jima and Ilu Aba Bor zones. Hot pepper seedling disease severity of CLS (92.5%) and Damping off (44.4%) were recorded which hot pepper seedlings were sown on flat seedbed type in Jima zone and 96% and 72% in Ilu Aba Bor zone respectively. In all the surveyed areas the least amount of hot pepper seedling diseases were recorded on raised seedbed type. In contrast, the majority of farmers were sown on flat seedbed type.

Among cropping pattern, 75% of the interviewed farmers were used crop rotation after producing hot pepper with Maize crop and Haricot bean; the remaining 25% of the farmers were used continuous mono-cropping in Jima zone. In contrast to this 77% of the interviewed farmers were used continuous mono-cropping and the remaining 23% of the farmers were used crop rotation with Maize and other cereal crops in Ilu Aba Bor zone. The year intervals and the types of the crops which were used for rotation differ from farmers to farmers and districts to districts. About 65% of farmers applied crop rotation for one year only and grew corn and beans after hot pepper and 35% of farmers applied crop rota-

tion for two years and grew corn and beans after hot pepper in Jima zone. In contrast to this about 30% of the farmers were apply crop rotation only for one year and cultivated Maize and other cereal crops in Ilu Aba Bor zone. According to the results, the disease severity of hot pepper seedlings CLS (85.2% and 76%) and Damping off (44.4% and 64%) were farmers used continuous mono-cropping system in Jima and Ilu Aba Bor zones respectively. However, most of fungal and bacterial pathogen that caused red pepper disease once appeared can able to survive in the soil at least five years [30].

The amount of fertilizer to be applied depends on soil fertility, fertilizer recovery rate, organic matter, nitrogen (N) mineralization in the soil, and nitrogen leaching in the soil [5]. Phosphorus is thought to result in higher yield and redder fruits [17]. During growth, more nitrogen can be applied to achieve better yield. Fertilizer requirements vary depending on soil type and previous crop history. Thus, a balanced level of nutrients is necessary for maximum production. In Ethiopia, the recommended application rate of 200 kg/ha DAP and 100 kg/ha urea is for red pepper or hot pepper [8]. According to the results, about 79% used NPSB + and 21% compost at the seedling stage of hot pepper in Jima area. About 50% used NPSB + and 50% did not use any other fertilizer at the seedling stage of hot pepper in Ilu Aba Bor area. According to the results, no farmer used UREA in all the studied areas. While the amount of NPSB + and compost used varied according to the studied areas. About 80% of farmers used less than the required amount of NPSB+ while the rest used the same required amount of NPSB+ in the Jima area.

Pesticide is one of the anti-biotic chemical uses to kill the pest affect production of different crops. In contrast to this the farmers were not used any pesticide for the control of hot pepper seedling diseases in the surveyed areas. Many farmers were didn't have the awareness to spray pesticides when hot pepper seedlings get sick. This finding agrees with [3].

Table 1. Characteristic features of Agronomic Cultural practices for Hot pepper seedlings.

Cultural practices variables	Class	Jima zone		Ilu Aba Bor zone	
		Assessed fields	Practiced work	Assessed fields	Practiced work
Seed varieties	Improved variety	28	0%	26	0%
	Local own seeds extraction	28	4 (14.3%)	26	8 (31%)
	From Local Markets	28	24 (85.7%)	26	18 (69%)
seed bed types	Flat seedbed	28	26(93%)	26	21(81%)
	Raised seedbed	28	2(7%)	26	5(19%)
	Normal	28	15(54%)	26	13(50%)
Crop density	Highly dense	28	10(36%)	26	13(50%)
	Scattered	28	3(0.1%)	26	0%

Cultural practices variables	Class	Jima zone		Ilu Aba Bor zone	
		Assessed fields	Practiced work	Assessed fields	Practiced work
Planting Methods	Row	28	12(43%)	26	0%
	Broadcasting	28	16(57%)	26	26(100%)
	Normal	28	22(79%)	26	20(77%)
Planting Time	Early	28	2(7%)	26	0%
	Late	28	4(14%)	26	6(23%)
	Mono-cropping	28	7(25%)	26	20(77%)
Cropping system	Rotation	28	21(75%)	26	6(23%)
	Intercropping	28	0%	26	0%
	NPSB+	28	22(79%)	26	13(50%)
Fertilizer used and types	UREA	28	0%	26	0%
	Compost	28	6(21%)	26	0%
	Unused	28	0%	26	13(50%)
	Mancozeb	28	0%	26	0%
Chemical used and types	Ridomil	28	0%	26	0%
	Unused	28	28(100%)	26	26(100%)

Table 2. Characteristic features of major hot pepper seedling diseases severity in Jima and Ilu Aba Bor zones.

Variables	Class	Major Hot pepper disease severity						
		Jima Zone			I/A/Bor Zone			
		LB	Damp	CLS	LB	Damp	CLS	Viral D+s
Altitude	Mid (1951-2530)	0	18.2	93.8	0	0	0	0
	Low (1500-1950)	9.1	68.8	100	12	76	100	8
Varieties	Improved	0	0	0	0	0	0	0
	Local	3.7	48.1	96.3	12	76	100	8
Seed bed types	Flat	3.7	44.4	92.5	12	72	96	4
	Raised	0	3.7	3.7	0	4	4	4
	Early	0	48.2	0	0	76	0	0
Planting Time	Normal	3.7	0	88.9	12	0	100	8
	Lately	0	0	7.4	0	0	0	0
Cropping pattern	Mono-cropping	3.7	44.4	85.2	12	64	76	8
	Rotation	0	3.7	11.1	0	12	24	0
Planting Methods	Row	3.7	18.5	44.4	0	0	0	0
	Broadcasting	0	29.6	51.8	12	76	100	8

3.2. Prevalence, Incidence and Severity of Hot Pepper Seedling Diseases in Jima and Ilu Aba Bor Zones

Cercospora leaf spot (*Cercospora capsica*), Damping off, Bacterial leaf blight and viral diseases were the Major Hot pepper seedling diseases in both Jima and Ilu Aba Bora Zones. The prevalence of *Cercospora* leaf spot (*Cercospora capsica*) was the highest hot pepper seedling disease recorded in Jima and Ilu Aba Bora areas, with a prevalence of 100% and a high level of incidence and severity. Damping off was the second seedling disease recorded in Nadi Gibe district of Jima Zone and followed by Omo Nada and Karsa districts of Jima zone with prevalence of 22.2%, 19.4% and 11.1% re-

spectively. Similarly, Damping off disease prevalence was the second disease recorded in Darimu district of Ilu Aba Bora zone with the prevalence of 46% followed by Halu and Bure districts with the prevalence of 37% and 31.5% respectively. Bacterial leaf blight disease prevalence was recorded only in Nadi Gibe district of Jima zone and Halu district of Ilu Aba Bora zone with the prevalence of 18.5% and 29.6% respectively. Similarly, viral disease prevalence was recorded only in Halu district of Ilu Aba Bora zone with the prevalence of 27.8% (Table 1). Sharma (2001) [26] explained that seedling diseases are caused by a variety of pathogens including *Fusarium oxysporum*, *Phytophthora* spp. and others.

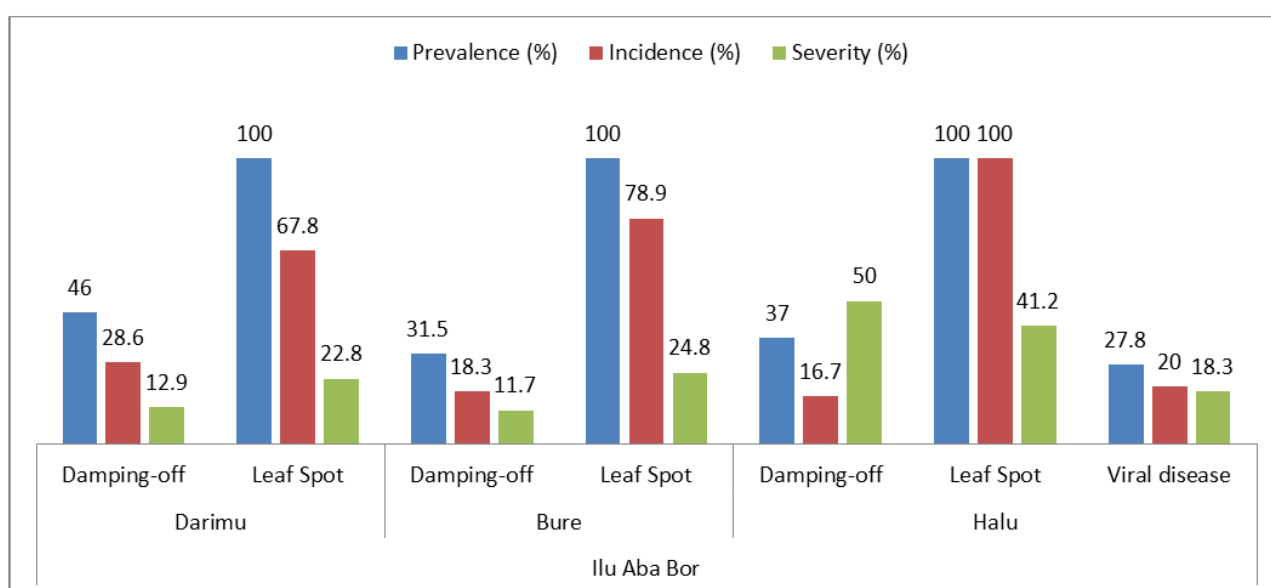


Figure 1. Prevalence, Incidence and Severity percentage of hot pepper seedling diseases in Ilu Aba Bor Zone.

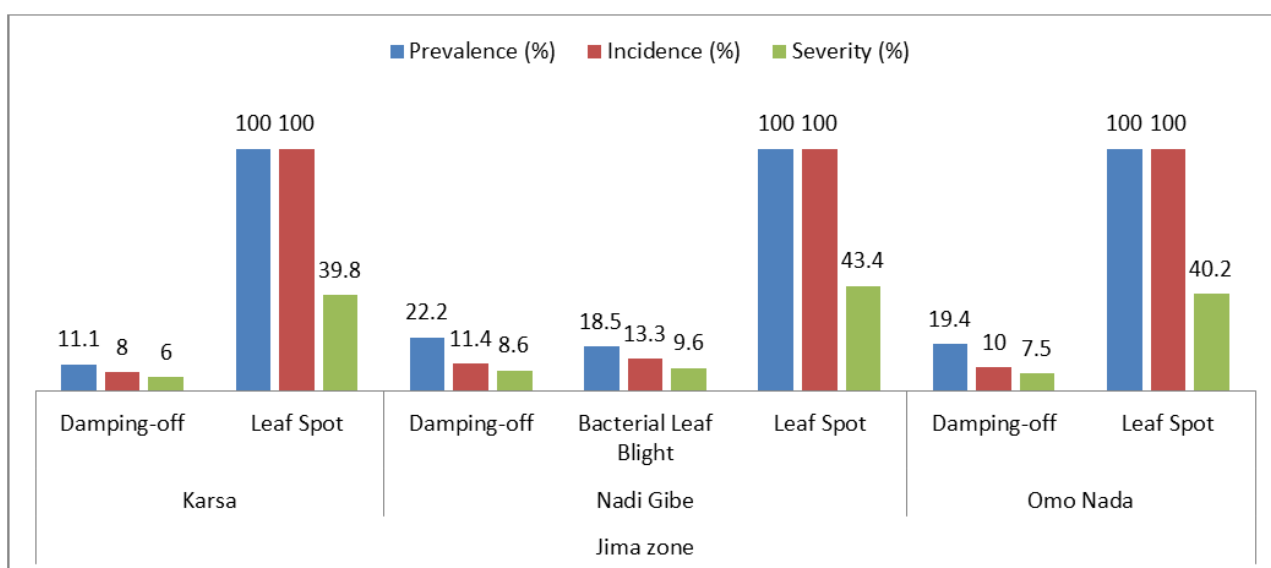


Figure 2. Prevalence, Incidence and Severity percentage of hot pepper seedling diseases in Jima Zone.

3.3. Characteristic Features of Agronomic Cultural Practices and Major Transplanted Hot Pepper Diseases Severity

Despite the good start, the cultural practices of hot pepper grower farmers in the areas were conducting survey still showed many shortcomings. During the survey, hot pepper diseases in all survey sites were problems of farmers' cultural practices. Most of the diseases seen in Hot pepper plantations can be controlled with recommended cultural practices such as optimum fertilizer rate, row planting, proper spacing, crop rotation and use of improved varieties. However, in the study districts, farmers' practices varied and only a few followed the recommended cultivation practices. For example, in both the study areas, seedbed preparation and emergence of hot pepper were not practiced at all by farmers. Except for a few farmers who use row sowing method, the most of them were plant directly using broadcast method of sowing on the flat seedbed or main field in both Jima and Ilu Aba Bora zones. Such cultural practices have made the hot pepper seedlings vulnerable to disease due to lying under flooding. Of all the hot pepper farms inspected, 5 (18%) used the broadcast planting method in the Jima area. The remaining 23 farmers (82%) used row planting. Even those that used row planting used narrower spacing than recommended. The recommended spacing between and within plants for hot pepper is 70 and 30 cm respectively, but the farmers used 35 and 20 cm respectively. This shows that farmers in the region do not know how to use spacing to reduce the incidence of diseases. All farmers in the inspected area used fertilizer during sowing and planting, but the amount of fertilizer used varied among farmers in Jima and Ilu Aba Bora zones. Out of twenty-six transplanted hot pepper were assessed fields 14 (54%) farmers were used NPSB⁺ fertilizer with different rate which was recommended or not in Ilu Aba Bor zone. About 8 (31%) farmers were used both NPSB⁺ and UREA fertiliz-

ers in Ilu Aba Bor zone. Regarding the use of fungicides, farmers did not use fungicides for seed treatment, seed spraying and farmers used fungicides after transplanting pepper plants, while 14 (50%) and 12 (46%) of the farmers used chemicals (mancozeb) against pepper diseases and 14. (50%) and 14 (54%) of the farmers did not use chemicals against pepper diseases in Jima and Ilu Aba Bor zone respectively. Several improved nursery management practices, including pepper seed treatment, use of recommended seeding rates, row sowing and row planting of seedlings, are known to have shown better results in improving production and productivity [11]. All of the interviewed farmers used rotation after producing hot pepper except 6 (21%) in Jima zone and 8 (31%) in Ilu Aba Bor zone used mono-cropping system; however the year interval and the type of crop used for rotation varied from farmers to farmers. About 22 (79%) and 18 (69%) of the farmers used rotation only for one year and planted maize after hot pepper in Jima and Ilu Aba Bor area respectively. But most pepper diseases caused by fungal and bacterial pathogens once they appear in the area can survive for at least three years in soil debris.

Farmers in the study area use hot pepper seeds from different sources. Of the farmers interviewed, 4 (14.3%) and 8 (31%) used their own seeds, 24 (85.7%) and 18 (69%) used seeds purchased from the local market in Jima and Ilu Aba Bor areas respectively. while 0% of the farmers did not use seeds of improved hot pepper varieties. However, it is known that seeds purchased from the local market and seeds grown in traditional ways are unreliable and more susceptible to attack by seed borne pathogens and play a role in the transmission of diseases in nurseries. Contaminated seeds and soil have been reported to be sources of inoculum affecting seedlings before or after emergence. To avoid such problems, Sharma [26] stated that field cultural control measures are key elements for disease control, but it all starts with the seed.

Table 3. Characteristic features of Agronomic Cultural practices for Transplanted Hot pepper.

Cultural practices variables	Class	Jima zone		Ilu Aba Bor zone	
		Assessed fields	Practiced work	Assessed fields	Practiced work
seed bed types	Flat seedbed	28	25(89%)	26	21(81%)
	Raised seedbed	28	2(7%)	26	0%
	Ridge seedbed	28	1(4%)	26	5(19%)
Crop density	Normal	28	14(50%)	26	13(50%)
	Highly dense	28	11(39%)	26	8(31%)
	Scattered	28	3(11%)	26	5(19%)
Planting Methods	row	28	23(82%)	26	26(100%)
	broadcasting	28	5(18%)	26	0%

Cultural practices variables	Class	Jima zone		Ilu Aba Bor zone	
		Assessed fields	Practiced work	Assessed fields	Practiced work
Planting Time	Normal	28	20(71%)	26	18(69%)
	Early	28	0%	26	0%
	Late	28	8(29%)	26	8(31%)
Cropping system	Mono-cropping	28	6(21%)	26	8(31%)
	rotation	28	22(79%)	26	18(69%)
	intercropping	28	0%	26	0%
Fertilizer used and types	NPS	28	23(82%)	26	14(54%)
	UREA	28	5(18%)	26	0%
	NPS & UREA	28	0%	26	8(31%)
	Compost	28	0%	26	0%
	unused	28	0%	26	4(15%)
Chemical used and types	Mancozeb	28	14(50%)	26	12(46%)
	unused	28	14(50%)	26	14(54%)

Table 4. Characteristic features of major transplanted hot pepper diseases severity in Jima and Ilu Aba Bor zones.

Variables	Class	Major Hot pepper disease severity						
		Jima Zone			I/A/Bor Zone			
		LB	Damp	CLS	LB	Damp	CLS	Viral D+s
Altitude	Mid (1951-2530)	0	68.8	93.8	0	0	0	0
	Low (1500-1950)	9.1	18.2	100	12	76	100	8
Varieties	Improved	3.7	18.5	37	4	28	40	8
	Local	0	29.6	59.3	8	48	60	0
Seed bed types	Flat	3.7	44.4	92.5	12	72	96	4
	Raised	0	3.7	3.7	0	4	4	4
Planting Time	Early	0	0	0	0	0	0	0
	Normal	3.7	48.2	88.9	12	76	100	8
	Lately	0	0	7.4	0	0	0	0
Cropping pattern	Mono-cropping	0	3.7	11.1	12	64	76	8
	Rotation	3.7	44.4	85.2	0	12	24	0
Planting Meth-ods	Row	3.7	18.5	44.4	0	0	0	0
	Broadcasting	0	29.6	51.8	12	76	100	8

3.4. Prevalence, Incidence and Severity of Transplanted Hot Pepper Diseases in Ilu Aba Bor and Jima Zones

3.4.1 Prevalence Disease

The main diseases affecting peppers after transplanting in the surveyed area were *Cercospora* leaf spot (*Cercospora capsici*), blossom end rot (*Alternaria* spp.), wilt (*Fusarium oxysporum*), anthracnose (*Colletotrichum gloeosporioides*) and bacteriosporias. *campestris* pv. *vesicatoria*) in the Jima and Ilu Aba Bora areas. In the previous study, Mohamed and Getachew [22] reported that peppers can be affected by a number of diseases after transplanting, in addition to damping off. Mengistu [20] and Temam [31] also reported powdery mildew (*Leveillula taurica*) and fusarium wilt (*Fusarium oxysporum*) as the most prevalent fungal diseases of peppers in Ethiopia.

The average prevalence of each disease symptom in the study area varied depending on the pathogens. Approximately 100% of the farms assessed had leaf spots due to *Cercospora* leaf spot (*Cercospora capsici*) in both Jima and Ilu Aba Bora zones. Blossom end rot disease was recorded in Darimu, Halu and Bure districts of Ilu Aba Bora zone with the prevalence of 50.6%, 40.7%, and 35.2% respectively. Similarly, it was recorded in Omo Nada, Nadi Gibe and Karsa districts of Jima zone with the prevalence of 22.2%, 20.4% and 18.1% respectively. Like to the other diseases, *Fusarium* wilt disease was also recorded in Darimu, Halu and Bure districts of Ilu Aba Bora zone with the prevalence of 46%, 43.2% and 30.2% respectively and it was recorded in Karsa, Omo Nada and Nadi Gibe districts with the prevalence of 19.4%, 17.5% and 15.3% respectively. Likewise, Anthracnose disease was recorded in districts of both Jima and Ilu Aba Bora zones. It was 33.3%, 19.4% and 17.8% prevalence in Halu, Bure and Darimu districts of Ilu Aba Bora Zone and 18.5%, 14.8% and 13% prevalence in Nadi Gibe, Omo Nada and Karsa districts of Jima zone respectively. Bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria*,) were other diseases of transplanted hot pepper recorded only in Ilu Aba Bora zone. Bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria*,) was only recorded in Halu district with the prevalence of 25.9% (Table 2).

3.4.2. Disease Incidence

Similar to the prevalence of *Cercospora* leaf spot the highest mean infection of *Cercospora* leaf spot were recorded in all surveyed districts of Jima and Ilu Aba Bora zones with the incidence of 100% followed by Blossom end rot recorded

in Darimu, Halu and Bure districts of Ilu Aba Bora zone with the incidence of 27.8%, 26.7% and 23.3% respectively. In Jima Zone, the highest mean infection of Blossom end rot was recorded in Omo Nada district with the incidence of 16.3% were followed by Nadi Gibe (13.3%) and Karsa (12.5%) districts. Accordingly, the mean infection of *Fusarium* wilt were recorded in Halu, Darimu, Bure, Karsa, Nadi Gibe and Omo Nada districts with the incidence of 21.1%, 18.6%, 14.3%, 12.5%, 11.3% and 10% respectively. Leaf curly disease was recorded only in Halu and Bure districts of Ilu Aba Bora zone with the incidence of 16.7% and 12% respectively. Similarly, the Bacterial leaf spot disease was recorded only from Halu district of Ilu Aba Bora zone with the incidence of 13.3% (Table 2). Among major hot pepper diseases were recorded in both zones, the highest mean incidence of Anthracnose was recorded in Darimu district with incidence of 14% followed by Halu and Bure districts with the incidence of 13.3% and 12.5% respectively. The least mean incidence of anthracnose disease was recorded in Nadi Gibe followed by Karsa and Omo Nada districts with the incidence of 6.7%, 8.3% and 10% respectively (Table 2).

3.4.3. Disease Severity

The same to recorded in disease prevalence and incidence of transplanted hot pepper, *Cercospora* leaf spot was recorded with the highest disease severity in the surveyed districts of Karsa, Omo Nada and Nadi Gibe of Jima zone with the disease severity of 39.5%, 36.7% and 35.4% respectively, and it was recorded in Halu, Darimu and Bure districts of Ilu Aba Bora zone with the disease severity of 37.9%, 34.7% and 33.5% respectively. Blossom end rot was also recorded in the districts of Darimu, Bure, Halu, Omo Nada, Nadi Gibe and Karsa with the disease severity of 21.1%, 19.8%, 17.6%, 10.6%, 10% and 9.9% respectively. Similarly, *Fusarium* wilt was recorded in Darimu, Halu, and Bure districts of Ilu Aba Bora zone with the disease severity of 12.9%, 12.2% and 7.1% respectively. It was recorded with minimum disease severity in Karsa, Nadi Gibe and Omo Nada districts of Jima zone with the severity of 5%, 7.5% and 8.6% respectively. This result shows similar trend with the findings of Shiferaw and Alemayehu [27] who indicated that the occurrence of *Fusarium* wilt was the highest at Abeshge (55%) followed by Halaba (41%), Hawassa Zuria (36%), Dalocha (32%) and Lanfro (30%) and other Western parts of Ethiopia. Accordingly, Anthracnose was also recorded in the districts of Darimu (11.5%), Bure (9.4%) and Halu (8.9%) districts and Nadi Gibe (7.4%) and same in Omo Nada and Karsa (6.7%) districts. Bacterial leaf spot was recorded only in Halu district (5.2%) (Figure 3).

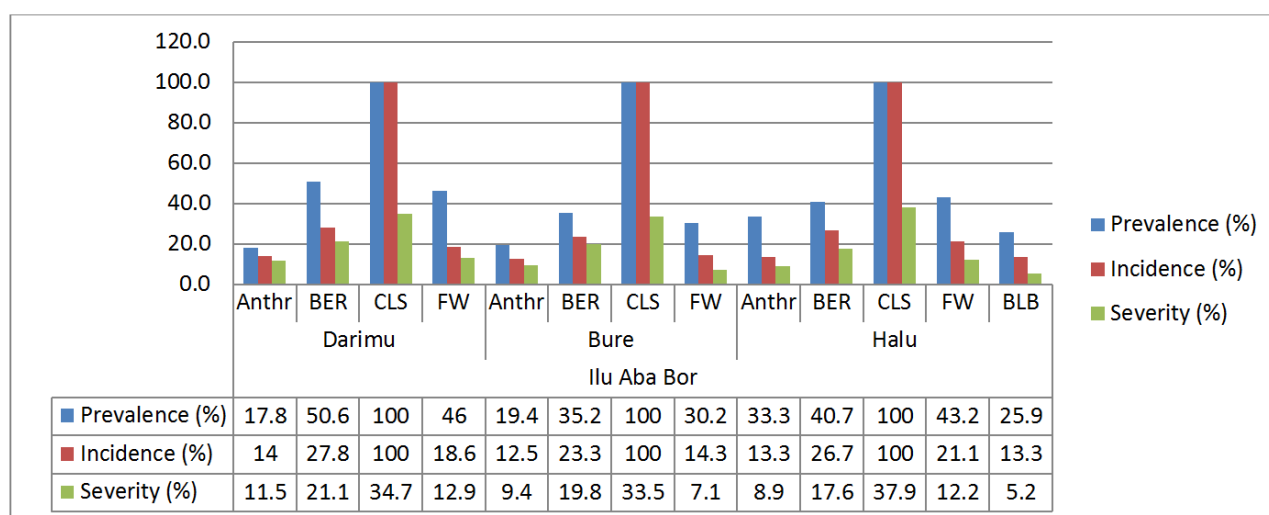


Figure 3. Prevalence, Incidence and Severity percentage of transplanted hot pepper diseases in Ilu Aba Bor Zone.

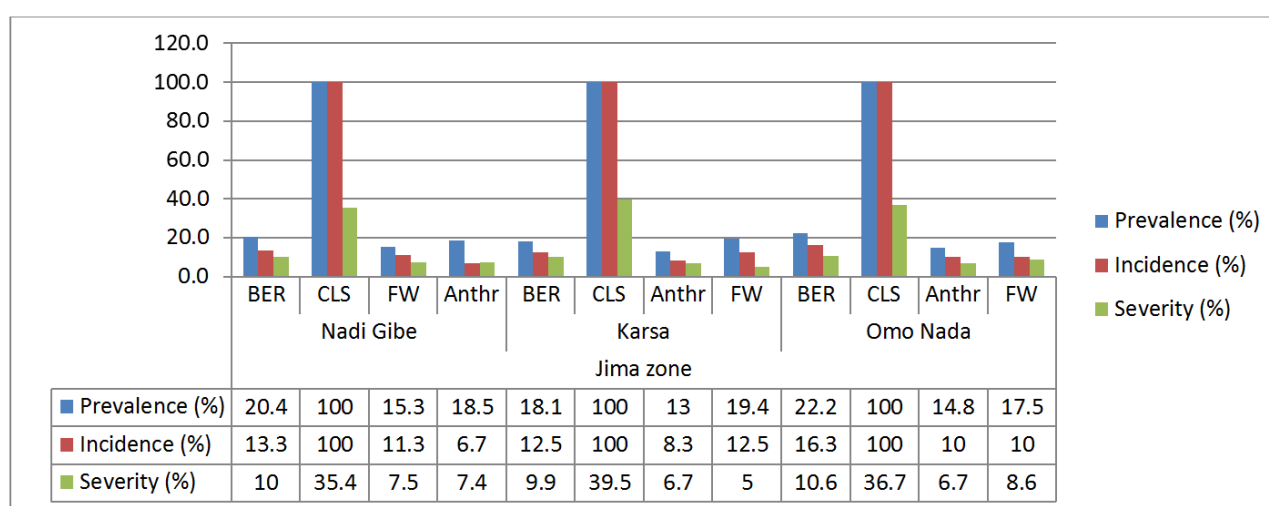


Figure 4. Prevalence, Incidence and Severity percentage of transplanted hot pepper diseases in Jima Zone.

4. Conclusion and Recommendation

The decline in hot pepper production is also attributed to poor varietal quality, poor cultivation practices, prevalence of fungal and bacterial diseases and viral diseases [10]. A number of factors affect hot pepper production in Ethiopia. These factors include lack of extension services, diseases, lack of improved seeds, lack of access to market centers and others such as bird attacks [14]. Although yield loss caused by each pathogen has not been clearly studied and quantified in Ethiopia, this study demonstrated the presence of complex diseases in the seedling and later growth stages of hot pepper. In this study, more than nine species of pathogens attacking hot peppers were observed in several districts. *Cercospora* leaf spot (*Cercospora capsica*), Damping off, Bacterial leaf blight and viral diseases were the Major Hot pepper seedling diseases in both Jima and Ilu Aba Bora Zones. The main

diseases found to infect hot pepper after transplanting in the inspected area were *Cercospora* leaf spot (*Cercospora capsica*), blossom end rot (*Alternaria* spp.), *Fusarium* wilt (*Fusarium oxysporum*), anthracnose (*Colletotrichum gloeosporioides*) and bacterial spot (*X. campanthomonas* sp. pv. *vesicatoria*) in Jima and Ilu Aba Bora Zones.

Many efforts were made in the region to manage the diseases through training and demonstration on improved agronomical practice and other recommended disease management packages from seedling rising till post-harvest handling. However, farmers' adoption study indicated application of recommended improved cultural practice on hot pepper production in the region is very low. Farmers in the region are still using poor cultural practices to produce hot pepper. Therefore, efforts should be made towards the integration of multiple control options. These are development of resistance varieties, seed treatment before sowing, and implementation of improved agronomic practices; apply recom-

mended fungicides, use the appropriate seedbed type for seedling preparation, raise awareness among farmers and experts, from site selection to post-harvest treatment, on the importance of diseases and their management. Overall, a holistic, integrated, cumulative approach is urgently needed to manage the complex diseases emerging in the region.

Abbreviations

EEPA	Ethiopian Export Promotion Agency
CSA	Central Statistical Agency
BARC	Bako Agricultural Research Center
m.a.s.l.	Meter Above Sea Level
CLS	Cercospora Leaf Spot
MoARD	Ministry of Agriculture and Rural Development
DAP	Di Ammonium Phosphorus
EARO	Ethiopian Agricultural Research Organization
OARI	Oromia Agricultural Research Institute
BeARC	Bedele Agricultural Research Center
LB	Leaf Blight

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Author Contributions

Takele Kusa: Conceptualization, Data curation, Formal Analysis, Methodology, Project administration, Software, Supervision, Writing – original draft, Writing – review & editing

Latera Dore: Conceptualization, Methodology

Jara Regassa: Conceptualization, Visualization

Conflict of Interest

The authors declare no conflicts of interest.

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Research Field

Takele Kusa: Karsa, Omo Nada, Nadi Gibe, Bure, Darimu, Halu
Latera Dore: Karsa, Omo Nada, Nadi Gibe, Bure, Darimu, Halu
Jara Regassa: Karsa, Omo Nada, Nadi Gibe, Bure, Darimu, Halu