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Research Article

Spatial Distribution and Association of Chickpea Wilt/Root Rots Epidemics with Biophysical Factors at West Shewa, Oromia Regional State, Ethiopia

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ABSTRACT

Chickpea (*Cicer arietinum* L) is one of the important grain legume crops in Africa particularly in Ethiopia which widely grown in marginal soils and usually as rotational crops in highland and semi-highland regions of the country and also as a source of cash to the farmers and foreign currency in Ethiopia. However, its production is totally affected by many pest and diseases. Among biotic stresses, wilt or root rot diseases are considered as the major problems in chickpea production. Therefore, the present study was conducted to determine the assessment of chickpea wilts disease intensity, in West Shewa, Ethiopia. Field survey was carried out in purposively selected Kebeles of Ambo and Dendi districts of West Shewa, Ethiopia. The results of the study revealed that, among 70 chickpea fields surveyed in both districts, the overall mean prevalence and incidence of the disease were 92.9%, and 35.09%, respectively. The higher prevalence and incidence of the disease was recorded in Ambo district with 40.96% and 93.5%, respectively while, in Dendi district it was 29.10% and 92.3%, respectively. Therefore, proper weed management practices, planting improved varieties and other related farm practices should be carried out to reduce wilt or rot impact until resistant chickpea genotypes are developed and distributed to major chickpea production regions of the country. Effective and feasible integrated management options need to be developed on chickpea wilt/root rot diseases in the country.

Keywords: *Cicer arietinum*; Chickpea Wilt; Root rots Pathogens; Disease incidence; Disease prevalence

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a highly nutritious pulse crop with good value of protein contents and therefore known as poor man's meat. It is usually grown under arid and semi-arid environmental conditions of the world [1] and one of the important grain legume crops in Africa particularly in Ethiopia which widely grown in marginal soils and usually as rotational crops in highland and semi-highland regions of the country [2]. Ethiopia is the largest producer of chickpea in Africa, accounting for about 46% of the continent's production during 1994-2016. It is also the seventh largest producer worldwide and contributes about 2% to the total world chickpea production [3-5]. Currently, it is one of the widely cultivated crops at the global level on 13.5 million hectares of area with a production 13.1 million tons [6]. It's a range of cultivation extends from the Mediterranean basin to the Indian sub-continent and south ward of Ethiopia and the East African highlands. The crop is native to Western Asia and the Middle East and it is usually grown as a rain-fed, cool-weather crop or as a dry-climate crop in semiarid region [7].

The chickpea also known as the garbanzo bean is an important source of protein in many parts of Central Asia, Africa, and the Mediterranean and among food legumes; it is the most effective in reducing blood cholesterol levels [8]. Chickpea returns significant amount of nitrogen to soil fertility and breaking the disease cycles of important cereal pathogens [3] and for this is main reason to use in rotation with several cereals like teff on heavy soils [9]. Chickpea has one of the highest nutritional compositions of among any dry edible legumes. On an average, chickpea seed contains 23% protein, 47% starch, 56% fat, 6% crude fiber, 6% soluble sugar, and 3% ash [10].

In Ethiopia, crops are grown annually on approximately 7.9 million hectares, which is appropriate to pulses. Pulse crops have diverse roles to play in the country and rank a second food after cereals and occupy about 17.7% of the total cultivated areas and contribute about 12% of the total production [11]. Ethiopia shares 2% among the most chickpea producing countries next to India (73.3%), Turkey (8%) and Pakistan (7.3%). Chickpea is one of the major pulse crop cultivated in the country, which occupies about 258,486.29 ha and from which annual production of 472,611.39

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tons of chickpea grain produced [12]. According to Bejiga et al., [13], the Ethiopian chick pea production is predominately about 95% by Dessi chick pea but in recent years, the interest of farmers in producing the large seeded Kabuli varieties increasing due to domestic and export market. The total annual average during 1999-2008 chickpea production is estimated at about 173 thousand tons [14]. The national average yield of chickpea in Ethiopia under farmers' production condition remains less than 2.0 tons ha-1[12]. A number of limiting factors contribute to low productivity of chickpea. The primary cause of low yields in chickpea is its susceptibility to a number of biotic and abiotic stresses.

Although, more than 70 pathogens have been reported so far on chickpea from different parts of world and a few of them are currently recognized as significantly important to chickpea production [15]. About 50 and 38% of these diseases are caused by fungal and viral pathogens, respectively [16].

Chickpea is attacked by a number of soil-borne and foliar diseases as well as field and storage insect pests in Ethiopia. Among the soil-borne diseases affecting chickpea, Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceri*), dry root rot (*Rhizoctonia bataticola*), collar rot (*Sclerotium rolfsii*) and black root rot (*Fusarium solani*) are the major yield-limiting factors, wherever the crop is grown in Ethiopia. The use of wilt-resistant chickpea varieties and adjustment of sowing dates are potentially cheap and easily adoptable methods in managing chickpea wilt. Developing and releasing wilt/root rot-resistant cultivars are the major objective of the National Chickpea Improvement Program (NCIP) and chickpea varieties having resistance to wilt/root rots have been released for cultivation in Ethiopia. Debre Zeit Agricultural Research Center (DZARC) is the premier institute for chickpea research in Ethiopia. An average chickpea yield in Ethiopia is usually below 2 tons/ha although its' potential yield is more than 5 tons/ha [14].

As chickpea is a rain fed crop and is grown under low input conditions, continuous seed treatment with fungicides are not possible [15]. Therefore, the importance of resistant cultivars is an established fact recognized by the researchers. Many sources of resistance to wilt pathogen, *Fusarium oxysporum* f. sp. *ciceri* have been reported mainly based either on field observations, during natural epidemics or on artificial inoculation either in the field or green house. Host resistance, however does not persist as varieties presumed to be wilt resistant failed, either as a result of genetic breakdown or a change in the virulence of the pathogen [16-18]. Since the host plant resistance provides the economical and the most practicable control of diseases, therefore, a reliable screening procedure is required for incorporating durable resistant in varieties. Conventional screening by using diseased plant debris or even spore suspension of a mixture of isolates is not as reliable as screening against individual virulent isolates [19]. A little information is available in germplasm evaluated for dual resistance against wilt/root rot pathogens due to their occurrence under contrasting environments in Western Showa, Ethiopia. Therefore, the present study was undertaken with the following objectives: Therefore, the objective of this study was to determine chickpea wilt/root rots disease prevalence, incidence and its association of with different agronomic practices on major chick pea growing districts of West Shewa zone of Ethiopia.

MATERIALS AND METHODS

Description of the study area

The survey of chick pea wilt disease intensity was conducted in two major chick pea growing districts of Ambo and Dendi of West Shewa zone in Oromia Regional State of Ethiopia (Figure 1), during the main cropping season of 2017/2018. The laboratory and glasshouse studies were conducted in Ambo Plant Protection Research Centre (APPRC).

Ambo is located 120 km west of Addis Ababa at 8°98' South latitude and 37°83' North longitude. It has a total geographical area of 83,598.69 sq. km., with elevation ranging from 1380-3300 m.a.s.l. Annual rainfall ranged from 900-1100 mm and temperature ranged from 10-27°C, with an average of 18°C. The soil type of the study site is vertisol with a pH value of 6.8. Dendi district is located in West Shewa administrative zone of Oromia Regional state at about 85 km west of Addis Ababa at North latitude of 8054N and East longitude of 380090E. The district has mean annual temperature ranging between 9.3-23.8°C and a mean annual rainfall of 750-1170 mm. Topography of the district covers 29% highlands and 71% midlands. The altitudinal ranges of the agro-climatic zones in the Dendi districts fall between 2000 and 3288 m.a.s.l.

Survey of chickpea wilt/root rots disease intensity

The survey was conducted from November to December 2017/18 in two districts of West Shewa zone namely; Ambo and Dendi districts. Purposive sampling was used to select eight Kebeles from Ambo district (Awaro kora, Gosu kora, Ileum Muja. Ilemu Jelina, Beyo kurbi, Amaro, Minini, Boja gebissa) and ten Kebeles from Dendi district (Awash bole, Awash boloto, Gatro lafto, Dhega wuchi, Wamura Sakoye, Werka werebo, Yobdo legbatu, Sunbela shiko, Golole bollo, Borecho gidu). These Kebeles were major chickpea producers in these two districts. Systematic sampling was applied to select farm fields in each kebele and all the accessible roads, every chickpea field after 5-10 next nearby fields from the first spot/field assessed were selected. A total of 70 chickpea fields (39 fields from Dendi district and 31 fields from Ambo district) in the areas were surveyed. Three-five spots per fields were assessed using 1 meter square quadrants and data was collected from individual chickpea plant in each quadrant. Chick pea wilt disease in the survey areas was observed and data on diseases prevalence and incidence was recorded and evaluated. The results of the survey were summarized by districts in the zone. In each field, plants within the quadrant were counted and recorded as diseased/infected and healthy/non-infected. The incidence of chickpea wilt disease was calculated by using the number of infected plants and expressed as a percentage of the total number of plants assessed.

Prevalence of the disease was calculated using the number of fields affected the disease divided by the total number of fields assessed and expressed in percentage.

Prevalence (%) = Number of fields affected the disease/Total number of fields assessed × 100

The incidence of wilt disease was calculated using the number of infected plants and was expressed as a percentage of the total number of plants assessed.

Disease incidence (%) = Number of infected plants/Total number of plants assesse × 100

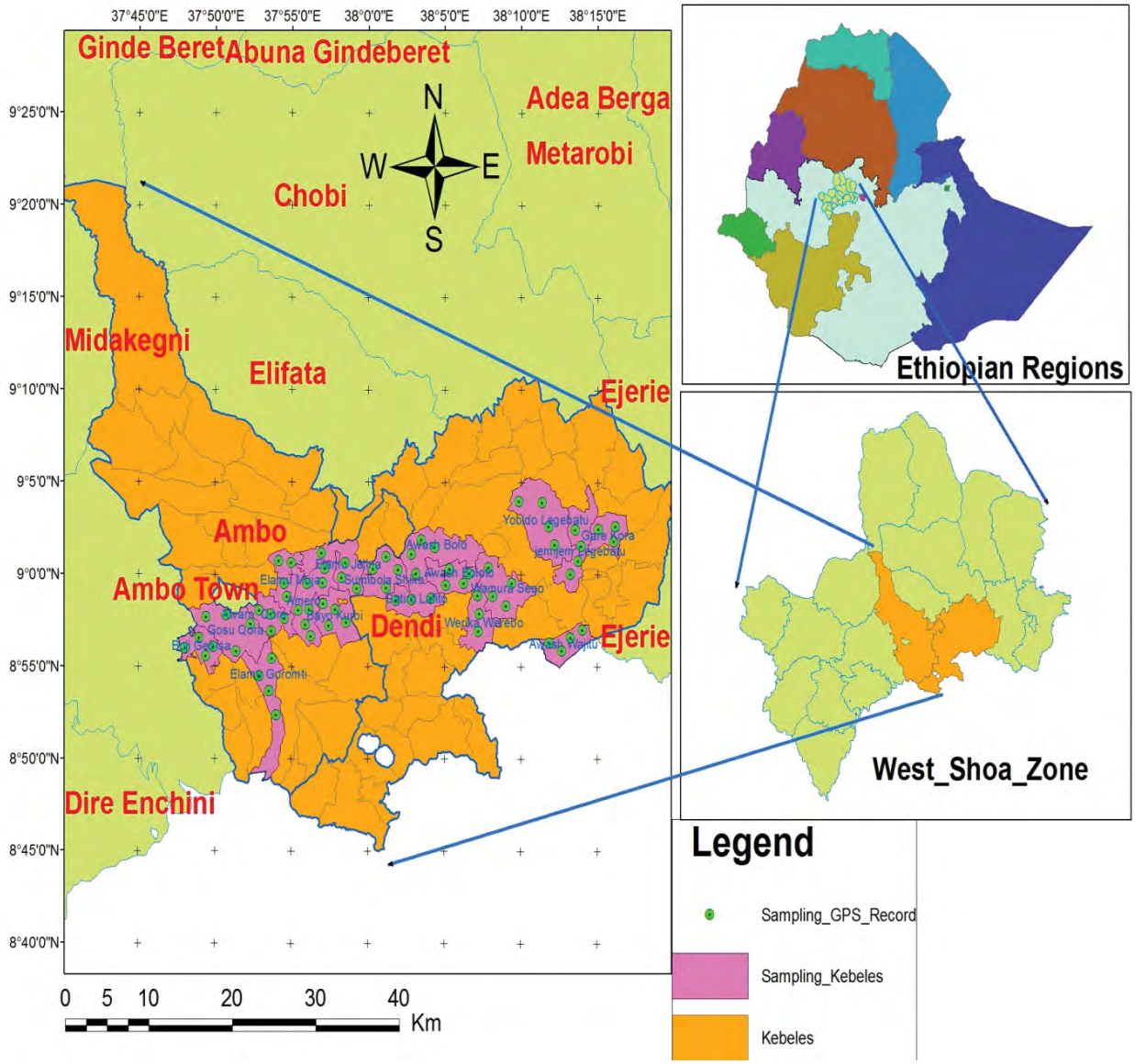

Figure 1: Map showing sampling points and surveyed districts of Ambo and Dendi for chickpea wilt or root rot disease in West Shewa of Ethiopia.

Moreover, data on geographical information (longitude, latitude, and altitude) of each field was recorded using GPS (Trex Legend GPS system, Garmin). The prevalence and incidence was analyzed by using statistical analysis (means) over districts and altitudinal ranges. In addition, supplementary information's like previous crop history, farmer's disease management practices, soil type, cultivar type, date of collection, plant growth stages, the symptoms of disease was collected using the survey report format.

Disease assessment and incidence

The incidence of chickpea wilt disease was calculated using the number of infected plants and expressed as a percentage of the total number of plants assessed (Table 1).

Disease incidence (%) = Number of infected plants/Total number of plants assessed × 100

Data analysis

The incidence data was analysed by using excel their mean over districts in different parameters namely altitudinal ranges, growth stages, previous crop, types of cultivars and across locations.

Table 1: The scale for disease incidence of infected chickpea varieties to the isolated wilt causing pathogens..

Scale	Percent disease incidence	Reaction
1	0-10%	Highly resistant
3	11-20%	Resistant
5	21-30%	Moderately resistant
7	31-50%	Susceptible
9	51-100%	Highly susceptible

RESULTS AND DISCUSSION

Intensity of chickpea wilt/root rots disease

Survey of chickpea wilt disease was carried out particularly in the major chickpea growing areas of both Ambo and Dendi districts (Figure 1) of West Shewa, Ethiopia. Among these two districts, a total of 70 chickpea fields (31 fields in Ambo district and 39 fields in Dendi district) were assessed. In the surveyed areas of all of the fields, the soil type was vertisol. Soil moisture plays an important role in the development of the crop. Knowledge on the irrigation facility and soil moisture status helps in determining the percentage of disease incidence.

During the survey in all the fields it was observed that none of chickpea fields were irrigated, the crop was cultivated under residual soil moisture or rainfall during the crop growth. As water logging is the key factor in predisposing the crop to infection, high weed infestation and high moisture in the soil were associated with the root rot incidence had significant contributions to the development of epidemics. According to Landa et al. [20] reported that indeed the temperatures around 28°C and accentuate water stress could be lead to higher disease incidence and the temperature has a significant influence on the development of the disease, the metabolic processes and plant development with pathogen and its virulence. Similarly, Andrabi et al. [21] reported that the environmental factors that influence the development of wilt pathogens as depends upon the moisture and temperature. Also Mehmood et al. [22] reported that the rain fall and soil variables (temperature and moisture) also had a significant positive effect on Fusarium wilt disease.

The results of the assessment of chickpea wilt/root rots disease intensity was varied across locations, growth stages of the crop, altitude ranges and type of variety and previous crops.

Intensity of chickpea wilt/root rots diseases related with the growth stages of the crop

During the assessment, 12.85% of the crop was at vegetative stage, 34.28% at flowering stage, 47.14% at podding stage and 5.71% is at full podding stage. The incidence of the disease at the vegetative stage was 18.60%, at flowering stage was 24.44%, at podding stage 30.00% and at full podding or ripening stage 36.33% (Table 2). This indicated that the intensity of chickpea wilt disease increased with increasing the developmental stages of the plant.

The observed difference in disease incidence might be due to the increasing of temperature that aggravate the disease spread since chickpea wilt/root rot diseases were temperature dependent and also the inoculum source where from a different point of views like infected seeds, soil and reintroduction of inoculum from infected plants that aggravate the disease through a time when coincides with the conducive environment such that favorable rainfall and humidity at an active growth rate of the pathogen as well as the plants. Similarly, Zemouli-Benfreha et al. [23] reported that the incidence of chickpea root rot disease increased with age of plants. The progress of time and the creation of new physiological stages of chickpea, the percentage of infected plants were increased. Increasing of percentage of infected plants, at reproductive in comparison with seedlings stage were due to increasing temperature [24]. *Fusarium oxysporum* f. sp. *ciceri* infects chickpea at seedlings as well as at flowering and pod forming stages, with more incidence at flowering and podding stage if the crop is subjected to sudden temperature rise and water stress [25].

Effect of precursor crops on intensity of chickpea wilt/root rots diseases

There was variation in previous cropping system with chickpea. Maize - chickpea cropping system was observed 12 fields where the disease incidence was 35.41% and wheat - chickpea cropping system was observed on 14 fields and the disease incidence was 22.5%. Barely - chickpea cropping system was observed on 18 fields where the disease incidence was 33.88% and teff - chickpea cropping system was recorded on 26 fields and the disease incidence was 25.84% (Table 3). There was no variation in chickpea fields surveyed in cropping system of all the fields were sow chickpea as a sole crop. Similarly, Srinivas [26] reported that there were variations in disease incidence due to the type of the cropping systems followed with chickpea.

Rani et al. [27] reported that the higher disease incidence may be attributed to previous crop, which may have aggravated the disease situation where in previous crop followed with sorghum, root exudates of sorghum may have reduced the inoculum load, leading to reduce the disease incidence. The type of previous crops grown, complex nature of pathogen leads to the buildup of inoculum of the pathogen in the soil over the seasons especially the population of *Fusarium oxysporum* when there was an optimum soil temperature and moisture caused more damage to the crop. Srinivas [26] also reported that the percent of disease incidence in sorghum - chickpea cropping system was 2.67% and in maize - chickpea cropping system, the percent disease incidence was ranged from 1.33% to 28.00% in the study areas. Misgana [28] reported that the severity of Fusarium root rot disease infection often depends on the previous crop history and species of Fusarium present in the soil.

Chickpea wilt disease intensity across locations

During the survey, wilt/root rots diseases were observed on 36 (92.3%) of the 39 chickpea fields assessed in Dendi district and 29 (93.5%) out of 31 chickpea fields inspected in Ambo district (Table 4). The disease intensity of chickpea wilt/root rots disease was high in Ambo district (93.5% mean prevalence and 40.96% disease incidences) than Dendi district (mean prevalence of 92.3% and 29.10% disease incidences) (Table 4). The overall mean disease incidence in both districts of Western Showa of Ethiopia was reached 35.03%. The observed difference in disease

Table 2: Prevalence and incidence of chickpea wilt/root rots diseases at different growth stages of chickpea during the cropping season of 2017/2018.

Growth stage	Altitude range (m.a.s.l)	Number of fields inspected	Prevalence (%)	Incidence (%)
Vegetative	1998-2474	9	77.77	18.6
flowering	1986-2428	24	91.66	24.44
Podding	1952-2427	33	100	30.00
Full podding	2028-2410	4	100	36.33

Table 3: Prevalence and incidence of chickpea wilt disease with regard to previous crops.

Previous crops	No. of fields assessed	No. of fields exhibited disease	Prevalence (%)	Incidence (%)
Teff	26	23	88.46	25.84
Maize	12	12	100	35.41
Wheat	14	13	92.85	22.5
Barely	18	18	100	33.88

Table 4: Prevalence and incidence of chickpea wilt/root rots diseases across locations.

District	Altitude Range	No. of fields inspected	No. of fields exhibit the disease	Prevalence (%)	Incidence (%)
Ambo	1952-2427	31	29	93.5	40.96
Dendi	2116-2474	39	36	92.3	29.10
Total	1952-2474	70	65	92.9	35.03

Table 5: Intensity of chickpea wilt/root rots across altitude range.

Altitude range (m. a. s. l)	Number of fields inspected	Prevalence (%)	Incidence (%)
1952-2200	29	93.1	41.55
2202-2392	31	90.2	32.71
2393-2474	10	80	17.52

Table 6: Intensity of chickpea wilts diseases among cultivars.

District	Cultivars	Total Fields	Prevalence (%)	Incidence (%)
Ambo	Local	18	100	54.44
	Improved	13	76.92	22.3
Dendi	Local	26	96.15	34.23
	Improved	13	84.61	18.84
Total Mean				32.45

intensity might be due to depending on the agro-ecological and environmental conditions prevailing in each locality, diversified weather conditions and variation in sowing dates in different fields.

Merkuz et al. [29] reported that Fusarium wilt/root rot diseases were found to be prevalent in almost all the surveyed chickpea-growing areas of Ethiopia. Similarly, the present study results were also consistent with Mengistu and Negussie [30], Meki et al., [31]. Similarly, Bekele [32] was found that the variations in occurrence of percentage of wilting in different cultivated fields of Utter Pradesh in India due to different locations, climatic conditions, variety of seeds sowing and soil types.

Intensity of chickpea wilt diseases across altitudes ranges

In Ethiopia, chickpea is cultivated at an altitude ranging from 1400 to 2300 m.a.s.l. [32]. The survey was conducted in major chickpea producing localities of the districts which falls in altitude range of 1952-2474 m.a.s.l. Out of the 70 chickpea fields inspected, 29 (41.42%) fields were found within the range of altitudes between 1952-2200 m.a.s.l. while 31 (44.28%) fields were found between 2202-2392 m.a.s.l. and the remaining 10 fields (14.28%) were found in altitude of 2393-2474 m.a.s.l (Table 5). In the altitude ranged from 1952-2200 m.a.s.l. the incidence and prevalence of chickpea wilt/root rot disease was 41.50% and 93.10%, respectively. Within in altitude ranged from 2202-2392 m.a.s.l., the chickpea wilt/root rot disease incidence and prevalence were 32.71% and 90.20%, respectively whereas within the altitude ranged from 2393-2474 m.a.s.l. the incidence and prevalence of chickpea wilt diseases were 17.55% and 80%, respectively. The highest disease incidence and prevalence were recorded in the altitude range found between 1952-2200 m.a.s.l. which was 41.55 and 93.1% while, the lowest disease incidence and prevalence were recorded in the altitude ranged from 2393-2474 m.a.s.l. which was 17.5% and 80%, respectively (Table 5).

These results indicated that the chickpea wilt disease incidence and prevalence was increased as the altitude range decreased and the disease incidence and prevalence decreased as the altitudinal range increased. This might be due to in the lower altitude or a lowland area which receives higher temperature and the environmental condition is so drier and warmer which leads to increase the disease incidence as compared to in the higher altitude or highland areas which has lower temperature and cooler environmental condition. Jeetendra [33] reported that Wilt disease symptoms were more severe at high temperature than lower temperature). This results have consistent with Singh et al., [34] reported that chickpea wilt disease is more prevalent in when the growing condition is relatively dryer and warmer than colder condition. Higher temperature and lower soil moisture and the environmental condition is warmer and drier in the lower altitude which predispose the crop to infection and resulted in increasing the disease incidence than higher altitude.

Intensity of chickpea wilts disease across chickpea cultivars

In both districts, among 70 cultivated fields, 44 fields were cultivated local chickpea variety and 26 fields were cultivated improved varieties. In Ambo district, out of 31 fields' assessed, 18 fields were cultivated local variety (58.06%) and 13 fields were cultivated with improved varieties (41.93%). Out 39 fields assessed in Dendi district, 26 fields were covered with local chickpea variety (66.66%) and 13 fields were covered with improved varieties (33.33%). The highest chickpea wilt disease incidence was recorded in local chickpea cultivars grown in cultivated field in Ambo (54.44%) and Dendi (34.23%) districts.

The lowest disease incidence was recorded in improved chickpea cultivars grown in fields of Ambo (22.30%) and in Dendi (18.84%) districts (Table 6). Similarly, the present study results were also supported by Mengistu and Negussie [30] reported that the incidence of chickpea wilt disease was found to be as high as 100% on local variety and 21% on improved varieties in north-western Ethiopia. The seeds of local cultivars were often used without any treatments by the farmers from season to another season which contributes to increasing the inoculum level in cultivated fields in Ethiopia. Farmers use their own reserved seeds from the previous harvest; without prior knowledge of the presence of primary inoculums in the seeds; which boost the intensity of the disease. Similarly, Ghosh et al. [35] reported that the local cultivars had a higher disease incidence with more severe disease symptoms when compared with the improved varieties in India.

CONCLUSION

The findings of the present study indicated that wilt/rot of chickpea incidence varies among districts, date of planting, types of variety, weed management and environmental factors. The present study revealed that proper weeding practices and planting improved variety, following of other related farm practices should be carried out to reduce yield loss of due to the diseases.

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