Journal of Agricultural Research Advances
ISSN: 2582-7227

Research Article
Open Access

Distribution associated agronomic practices and environmental factors of white rot disease at major garlic growing areas of north western, Ethiopia

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Received on: 22/07/2023 Accepted on: 27/10/2023 Published on: 05/11/2023

ABSTRACT

Aim: The aim of the study was to evaluate distribution and quantifying incidence and severity of garlic white rot disease and the associated environmental factors and cultural practices in northwestern Amhara region, Ethiopia.
Materials and Methods: Survey was conducted in twelve districts of 71 garlic fields in 2020/21 main cropping season. Field survey was conducted by using random sampling technique in 7-10 km intervals based on vehicle odometers following the main roads and accessible routes and growers were interviewed using structured questioner to obtain information on cropping systems and cultural practices.
Results: Survey results indicated that white rot was widely distributed in all garlic growing areas of the surveyed districts. The assessment results showed that about 47.89% of the fields were infested with white rot. Then, incidence of white rot was assessed by counting the number of plants showing white rot symptoms. Disease intensity was varied among districts, variety grown, plant density, cropping pattern, previous crop grown, tillage frequency, slop of fields, temperature, soil type and field management practices. Among the districts surveyed the highest 100% disease prevalence was recorded in Dera district followed by Bahirdar district recorded 75.0% disease prevalence. The higher disease incidence 43.33% was recorded in Dera district was as highest disease severity 55.71% was recorded in Yilmana Densa district.
Conclusion: It was concluded that disease prevalence varies with the variations of cultivar grown, soil type, plant density, cropping pattern, previous crop grown, slops of the field and tillage frequencies practices implemented on the fields. Higher white rot incidence and severity were recorded on vertisol type and previously garlic sown fields. Thus by crop rotations and plant garlic on nitisol can reduced the disease intensity.

Keywords: Garlic, sclerotiumcepivorum, disease severity, agronomic factors

How to cite this article: Bekele B (2023). Distribution associated agronomic practices and environmental factors of white rot disease at major garlic growing areas of north western, Ethiopia. J. Agri. Res. Adv., 05(04): 29-36.

Introduction

Garlic (*Allium sativum* L.) is the second most important Allium species next to onion (Getachew and Asfaw, 2000). It grows worldwide in all temperate to subtropical and mountainous tropical areas (Rabinowitch, 2002). Annual production and area coverage of garlic reached 30.7 million tons and 1.6 million hectares, respectively, in the world (FAO, 2019). It is also one of the most important vegetable crops widely grown for use as a flavoring condiment in foods in different parts of the world (Tindall, 1983).

In Ethiopia, the Alliums (onion, garlic, and shallot) are important bulb crops produced for home consumption as a spice, medicinal plant and as a source of income for farmers. Production of cash crops like garlic and other spices is proved to be income generating activity for farmers, especially for those who have limited cultivated land or small holder farmers. As a cash crop, it is a source of earning foreign currency by exporting to Europe, the Middle East, Africa and USA (FAO, 2006). The production of dried and processed garlic products are also used for food preparation and as dietary health-food supplements (Diriba, 2016). It has nutritional and health benefits such as for anticancer and antibiotic as well as compounds for the treatment of metabolic, cardiovascular and respiratory system diseases (Najda *et al., 2016).*

It grows in a wide range of climatic and soil conditions, mainly in the mid-altitudes and highlands of the country. West Gojjam, East Gojjam, Awi and South Gonderzones are among the main producers of garlic in the region. Also, DebreWork, Adet, Sinan and other areas of the Ethiopian highlands of Amhara regions produce the bulk of garlic (Getachew and Asfaw, 2000). Among the prominent factors for its low productivity in the country, white rot (*Sclerotiumcepivorum)*, isthe most destructive disease causing heavey losses (Coley-Smith JR 1987). It isthe most devastating fungal pathogen and has critical concerns to the crops because once the sclerotia are in the soil; they can stable for up to 40 years in the absence of host plant and this feature makes its control difficult. As a result a field infested with *sclerotiumcepivorum, Allium* cultivation may not be possible for many years (Amine *et al.,* 2014).

White rot is prevalent in many Allium growing regions ofthe worldwide and causes serious economic losses and becomes a serious threat of allium industry (Coley-Smith, 1987). It causes up to 100% yield loss in Mexico and Brazil and its productionis enforcedto abandon by some growers of garlic growing regions in somestates of Brazil due to the presence of high levels of sclerotia in soil (Earnshaw et al., 2000). In Ethiopia, A yield loss of up to 53.4% has been reported.In northern Shewa Ethiopia, 37.28% to 42% white rot incidence was reported in farmers' fields (Tamire *et al.,* 2007). Mengistu (1994), also reported that garlic white rot become major problem in major garlic production area of the country. The can cause up to 100% yield lose in favorable weather conditions and susceptible varieties are in production system (Zeray, 2011). Host and soil effects are important in the survival of white rot. Among soils, wet soil like vertisol increased the disease incidence provided that the inoculum level was sufficient in the soil. On average, the temperature ranged from 7 to 22^{0}C was suitable for sclerotial germination and diseasedevelopment (Tamire *et al.*, 2007). On the other hand, the hardwalled sclerotia formed during infection are incredibly tough, and can remain dormant yet viable in the soil for many years (Maude, 2006). Soil temperature is the greatest factor contributing to the speed of disease movement; at 48° F germination is very slow; optimum at 57-64°F, and terminates at 70°F. The Ideal moisture levels required for disease development are the same as for crop growth. It is prevalent in many garlic growing regions worldwide, but its intensity can vary with different cultural practices and environmental factors (Schwartz and Mohan, 2008).

Management of diseases caused by soil borne pathogens, especially those that produce sclerotia is very difficult and needs effective management strategy. Crop rotation used for primary inoculums reduction (Banks and Edgington, 1989), but has been viewed as impractical for Allium white rot control due to the persistence and longevity of the sclerotia in the soil (Prados-Ligero *et al.,* 2002). Brix and Zinkemagel (1992), no (Allium species) shows a resistance difference among Allium species. Fungicides are among the most effective options for garlic white rot disease management. Systemic as well as non-systemic fungicides significantly reduced incidence of white rot, its progress rate, severity, and there by improved garlic yield. Tebuconazole was effective in reducing the incidence and progress of the disease, and in increasing the yield when applied as a clove treatment (Tamire *et al.,* 2007). As white rot disease has become a recurrent problem in major garlic production areas of the country, information obtained from survey work is important for planning management strategies. Therefore, this study was conducted with objectives to determine the incidence and prevalence of white rot, and its association with environmental factors and cultural practices.

Materials and Methods

The survey of white rot disease of garlic was conducted in major garlic-growing areas of Northwestern Ethiopia. The surveyed districts were Debre Elias and Gozamenin East Gojjam; Burie, Demibecha, Jabi Tehinan, Wonberema, Bahir Dar zuriaand YilmanaDensa inWest Gojjam; Fagita Lekuma and Guagusa Shekudad in Awi and Derain the South Gondar zones. Dataon disease prevalence, incidence and severity as well as data on agro-ecological factors were collected from districts during the 2020/21 main cropping seasons. The geographic location, altitudinal range, mean minimum and maximum temperatures, total seasonal annual rainfall, and mean relative humidity of the surveyed districts were presented (Table 1). Six growing months (May–October) weather data were obtained from the National Meteorology Agency, Bahir Dar Branch, Ethiopia.

Table 1. Altitudinal ranges, mean minimum and maximum temperatures, total annual rainfall and mean relative humidity of surveyed areas in Northwestern Ethiopia during 2021 main cropping seasons.

Districts	Altitude (m)[a]	Temp. (^{0}C)[b]		Total annual rainfall (mm)	Relative humidity (%)
		Min.	Max.		
Dembecha	1995-2054	10.7	26.5	1129.8	76.2
JabiTehinan	1818-2011	12.2	23.9	937.0	80.7
Burie	2037-2123	11.6	23.6	958.2	78.5
Wonberema	1936-2108	12.9	25.9	1361.1	79.8
Guagusa Shikudad	2256-2359	10.5	18.9	1605.7	68.5
Dera	1839-1921	11.3	23.4	1139.9	78.5
Yilmana Densa	2183-2317	11.4	18.5	1598.5	70.7
Gozamin	2023-2141	10.9	21.8	1247.2	65.0
Debre Elias	2045-2219	13.0	22.1	1453.8	76.2
Total /range	1801-2550	10.5-26.5		937.0-1605.7	65.0-80.7

[a]Altitude ranges of the surveyed districts were recorded using a global positioning system and m a.s.l.=meters above sea level.

Sampling Technique and Methods of Data Collection

Field survey was conducted by using random sampling technique of garlic fields in 7-10km interval based on vehicle odometers following the main roads and accessible routes in 2020/21 cropping season. The information was collected from those sampled garlic fields by using a structured interview. In each field, assessment wasconducted using quadrants (0.5m by 0.5m) by making diagonal moves in the field. The plant population in each quadrant was counted and average plant population in the quadrants was taken as mean plant population density. During the survey, altitude (m), type of soil, cropping pattern (row or broadcast planting), previous crop grown, slop of field, planting density and tillage frequency were recorded. Moreover, fertilizer utilization, weeding frequency, plant growth stage, disease-aggravating factors [i.e. flooding and waterlogging, extended rainfall and recycling of seeds of local susceptible cultivars and white rot management practices were collected using formal questionnaires and personal interviews with farmers. Data on geographical information (latitude, longitude and altitude) of each field was also recorded using a GPS (Legend GPS system, Garmin) to plot surveyed areas.

Disease assessment

Inspected fields for disease prevalence, incidence and severity were performed. The disease prevalence, was assessed as the number of fields affected per total number of fields inspected, calculated using the following formula.

$$\text{Disease prevalence }\% = \frac{\text{Number of fields showing wilt symptoms}}{\text{Total number of fields assessed}} x\ 100$$

Disease Incidence

To estimate the percent disease incidence each plant was counted including infected one in the field and then expressed in percentage. For the determination of disease incidence of garlic the following formula given by (Manandhar *et al.*, 2016) was used.

$$\text{Disease incidence }\% = \frac{\text{Number of diseased plants}}{\text{Number of total plants observed}} x\ 100$$

Disease Severity

Disease severity of white rot was computed by observing the level of damage by the pathogen using 0-5 scale and converted to percentage as follows by selecting 10 plants randomly from each plot and used for PDI (percent disease index) estimation.

Grade Symptoms are describe as follows; 0: No infection, 1: 1-10% infection, 2: 11-20% infection, 3: 21-30% infection, 4: 31-50% infection, 5: >50% infection

The percent disease index (PDI) was calculated according to the formula given by (Wheeler BE, 1969).

$$\text{PDI} = \frac{\text{Total sum of numerical ratings}}{Number\ of\ observations\ x\ maximum\ disease\ rating} x\ 100$$

Field survey analysis

Descriptive way of analysis was used to describe the disease prevalence, incidence, severity as well as its associations with environmental factors and agronomic practices.

Results and Discussion

General characteristics of surveyed fields

During the survey, a total of four zones and twelve garlic production districts were inspected. The surveyed fields'size ranged from 10 m^2 to 2500 m^2 and grows in their homestead for home consumption purpose. In the surveyed areas, farmers grow local cultivars and used their savedseeds for year to year production. The growers commonly applied Diamonium phosphate (DAP) during seedling establishment while nitrogen (UREA) was applied during the first weeding time. Growers in the area are well aware of the diseases and exercise different management options (seed dressing, sanitation, ash, rotation) to reduce the losses incurred by the disease. Most of growers were planted the crop in medium density plant population. Regarding planting pattern, 39 (54.93%) of the assessed fields were planted in a row cropping pattern, while the remaining 32 (45.07%) of the fields were planted in broadcast (Table 2).Farms with the highest (2550masl) altitude were assessed in FagitaLekuma district, while farms with the lowest (1801masl) were observed in Bahir Dar zuria district. Growers commonly applied nitrogen–phosphorus–sulphur–boron (NPSB) blended fertilizer during seedling establishment, while urea was applied during weeding periods after transplanting. Most growers used cultural management practices (crop rotation, sanitation, healthy clove) for white rot management. None of the garlic growers in the assessed fields utilized chemicals as seed treatment or foliar spray to combat white rot disease management except one grower. Among 71 fields assessed only 39 (54.93%) growers planted in row cropping pattern. In the area, 56.34% of the growers plough there farms three times whereas the remaining 25.35% and 18.31% of the growers cultivated two and four times respectively.

Disease prevalence

Disease Prevalence and Disease intensity across locations

The survey result revealed disease prevalence, disease incidence and severity were varied in the surveyed fields and districts. Accordingly, among 71 examined fields, about 47.89% were affected by white rot disease; while the remaining (52.11%) were disease free. In the season, disease prevalence reached up to 100% in Dera district, followed by YilmanaDensa (85.71%) district. Similarly, Bahir Dar zuria and JabiTehinan districts also recorded disease prevalence of 75.0% and 66.67% respectively. In the surveyed season, mean disease prevalence with range of 16.67-100.0% was recorded on the surveyed districts (Table 2).The highest mean disease incidence (43.33%) and disease severity (55.71%) were recorded in Dera and YilmanaDensa districts respectively, while the lowest mean disease incidence (3.33%) and severity (5.0%) were observed in Dembecha, Burie and Gozamin districts of the surveyed districts. Bahir Dar zuria district had the second highest mean disease incidence (25.0%) and disease severity of (40.0%)(Table 2).

The mean incidence and severity of garlic white rot was highest at Yilmana Densa with altitude range of 2183-2317 as compared to the other districts masl. This indicated that this altitude range might be favorable for the disease distribution and germination of sclerotia and hyphal growth. Ararsa and Thangavel (2013) also reported that cool weather is needed for germination of sclerotia and hyphal growth. Also, Tamire*et al.* (2007) reported that with, white rot disease incidence increased as elevation increased from 2450 to 3350 masl. Variation of temperature related to altitude was also resulted in difference mean incidence and severity of white rot. The mean minimum incidence (20.2 %) was obtained from temperature ranged from 6-17 °C. On the other hand, the mean maximum incidence (51.36 %) and severity (39.74 %) were from temperature ranged from 11.4-18.5°C (Table 1). Crowe and Hall (1980) also reported that sclerotial germination occurs between 9 and 24°C and disease development between 6 and 24°C (Table 2).

Association of disease intensity with agro ecological factors

During the assessment farmer's agronomic practices i.e. cultivar grown, soil type, plant density, previous crop grown, cropping pattern, slop of the fields and tillage frequencies practiced were recorded for each field.

Associations of White Rot with Cultivar Grown and Soil Type

White rot disease variation was also recorded on the types of cultivars grown (Table 3). Among the fields surveyed 92.96% of the growers planted local cultivars while only 7.04% of the growers used improved cultivars. Improved cultivars recorded a slightly lower mean disease incidence and severity of 10% and 18% and local once recorded 16.22% and 20.92% disease incidence and severity in the ordered mentioned. The result showed mild variations of white rot disease incidence and severity with cultivar variations. This may be due to many years of continuous cultivations of improved cultivars once in growers hands and becomes susceptibility for the disease. Also, Brix and Zinkemagel (1992) founds that, no (Allium species) is known which shows a consistently high degree of resistance to S. cepivorum and no difference in susceptibility exist among Allium species.

Regarding to soil type, disease prevalence and disease intensity variations were observed in the studied areas. Among the surveyed fields 57.75% were nitisol while the remaining 42.25% of the fields were vertisols. From the assessed fields a disease prevalence of 63.53% and 34.30% were recorded on vertisols and nitisols in the ordered mentioned. In the same time, fields characterized by nitisol types recorded lowered mean disease incidence of 10.12% and severity of 13.29% compared with farms of vertisol types recorded a disease incidence (23.84%) and severity of (30.50%) disease pressure (Table 3). Also, some vertisol fields recorded up to 100% disease severity. This might be due to the soil characteristics of conserving more moisture with low temperature; which favores white rot sclerotioa development. The same finding also reported by Shewakena *et al.* (2020), identified that *Sclerotiumcepivorum* severity is higher on vertisol than other soil types.

Associations of White Rot with Previous Crop Grown

The surveyed fields were planted different crops as a precursor crop. Disease incidence and severity of garlic white rot disease showed notable variations in relation to the previous crops sown in the surveyed fields. Among the total surveyed fields, 50.70% of the fields were sown cereal crops as a precursor crop. Whereas, 11.27% of the fields were continuously planted with garlic and the higher disease incidence of 19.38% and severity of 28.75% were recorded on these fields. Continuous growing of garlic leads to accumulation of the white rot sclerotia in the soil that increases the occurrence of white rot (Tamire *et al.,* 2007). Once the bulb is infected, the plant soon loses vigor, the leaves become yellow and wilt, and fluffy, white mycelia fill the bulb and then produce abundant sclerotia to precipitate future infections (Maude, 2006).While, the lowest disease incidence (10.8%) and severity (11.47%) were recorded on previously vegetable planted fields (Table 4). Also, fields planted with cereals and left uncultivated (fallow) as a precursor crop slightly reduced disease pressure in the area. This could be the sclerotia survival ability for many cropping seasons in the soil and the growers' experience of crop rotations in the area to be short. Since, sclerotia can be reached in 2-4 cropping cycles in the soil, Short periods of rotation with non-Allium crops has been viewed as impractical for the disease control due to the persistence and longevity in the soil. However research on long term rotations have shown that crop rotations require more time to significantly and effectively reduce soil borne pathogens (Larkin *et al.,* 2010; Wright *et al.,* 2015). The duration taken in the crop rotations highly determines the reduction of inoculum in the soil. Short term crop rotations have been shown to affect pathogen populations and disease status in the soil (Lemaga *et al.,* 2001; Narayanasany, 2013). In addition, crop rotation also used for primary inoculum reduction (Banks and Edgington, 1989).

Associations of White Rot with Cropping Pattern

Disease incidence and severity were also varies with cropping pattern of the farmers practice. The highest mean disease incidence (15.32%) and severity (31.46%) were recorded in fields planted in broadcasting cropping pattern. On the other hand, lower mean disease incidence (12.43%) and disease severity (13.54%) were recorded in fields planted in row cropping pattern (Table 4). Also, flat garlic fields recorded higher white rot disease pressure than fields planted on raised bed. This is because of raised bed allows the water to run off easily and does not permit water stagnations in the field which aggravates disease incidence. Broadcast cropping system of garlic, crop density was higher than row planting, which might be due to the increase in colonizing of the disease from infected plant to uninfected plant. Crowe (2008) also reported that uninfected roots within 1 to 2 cm of infected roots in contact with infected roots get colonized by hyphae from infected roots.

Associations of White Rot with Plant Density

Disease intensity was also showed variations with plant density. During the survey, lower disease prevalence (33.33%), incidence(8.0%) and severity of (13.33%) white rot disease were recorded in sparsely populated (lower plant density) fields as compared to fields with medium and higher plant density (Table 4). However, higher disease incidence (25.46%) and severity (30.46%) of white rot disease was recorded on densely populated fields than in sparsely populated fields. Crowe, F.*et al.,* (2008) also reported that uninfected roots within 1 to 2 cm of infected roots in contact with infected roots get colonized by hyphae from infected roots. Similarly, Tamire *et al.* (2007) and Shewakena *et al.* (2020) also reported; higher number of infected plants with white rot was recorded from densely populated fields than sparsely populated fields. This could be due to the from plant to plant. It is because offree movement and spread of sclerotiumrapidly to adjacent plants. Scott (1956) suggested that the white rot pathogen spreads fromplant to plant only at points of root contact. Plant-to-plant spread of the pathogen may increase the nutritional base on which inoculum is produced; the rapid increase in inoculum density from very low inoculum density levels (Crowe *et al.*, 1980).

Associations of White Rot with Slop of Field

Disease intensity also varies with the slop gradient of surveyed fields. Among the surveyed fields, 43 (60.56%) were categorized under flat slop gradient. The remaining 25 (35.21%) and 3(4.23%) were categorized under gentle and high sloppy gradient fields respectively. The highest disease incidence (16.51%) and disease severity (25.70%) were recorded on flat fields followed by gentle cropped fields with an incidence (9.0%) and severity of (15.0%). Whereas, the lowest disease incidence (8.33%) and severity (10.0%) were recorded on fields with high slop gradient. This might be due to low moisture availability of high sloppy fields for sclerotium to survive, germinate and transfer plant to plant.

Table 2. Geographic location, altitudinal range, disease prevalence, Disease incidence and severity of surveyed areas in Northwestern Ethiopia during 2021 main cropping seasons

Districts	Altitude (m)	Total fields	Prevalence%	Incidence%		Severity%	
				Range	Mean	Range	Mean
Dembecha	1995-2054	4	1(25)	0-40	10.00	0-20	5.0
JabiTehinan	1818-2011	6	4(66.67)	0-70	23.33	0-80	25.0
Burie	2037-2123	6	1(16.67)	0-40	6.67	0-30	5.0
Wonberma	1936-2108	9	2(22.22)	0-50	10.00	0-45	9.44
Guagusa Shikudad	2256-2359	6	2(33.33)	0-75	15.83	0-40	11.67
Fagita Lekuma	2317-2550	9	5(55.56)	0-100	15.56	0-80	20.0
Dera	1839-1921	6	6(100.0)	10-80	43.33	0-70	32.5
Bahirdar Zuria	1801-1828	4	3(75.0)	0-60	25.00	0-70	40.0
Yilmana Densa	2183-2317	7	6(85.71)	0-30	12.14	0-90	55.71
Gozamin	2023-2141	6	1(16.67)	0-20	3.33	0-30	5.0
Debre Elias	2045-2219	4	2(50.0)	0-30	10.00	0-100	26.5
Dangila	1932-2211	4	1(25.0)	0-40	10.00	0-50	12.5
Total /range	1801-2550	71	34(16.67-100)	0-100	3.33- 43.33	0-100	5.0-55.71

Table 3. Incidence and severity of garlic white rot associated with cultivars and soil type

Variables		No. of Fields	Prevalence%	Disease Incidence%		Disease Severity%	
				Range	Mean	Range	Mean
Cultivar	Improved	5	2(40%)	0-40	10.00	0-20	18.00
	Local	66	31(46.97)	0-100	16.22	0-100	20.92
Soil type	Nitisol	41	16(34.30)	0-75	10.12	0-80	13.29
	Vertisol	30	17(63.53)	0-100	23.84	0-100	30.50

Table 4. Incidence of garlic white rot associated with agronomic practices

Agronomic practice		No. of Fields	Disease Prevalence	Disease Incidence%		Disease Severity%	
				Range	Mean	Range	Mean
Plant density	High	11	7(63.64)	0-100	25.46	0-80	30.46
	Medium	45	21(46.67)	0-80	13.56	0-80	18.33
	Low	15	5(33.33)	0-30	8.00	0-60	13.33
Cropping pattern	Row planting	39	15(38.46)	0-100	12.43	0-80	13.54
	Broadcasting	32	18(56.25)	0-80	15.32	0-100	30.16
Slop of field	Flat	43	24(55.81)	0-100	16.51	0-100	25.70
	Gentle	25	8(32.0)	0-75	9.0	0-90	15.00
	High sloppy	3	1(33.33)	0-40	8.33	0-30	10.00
Previous crop	Cereal	36	14(38.89)	0-75	11.53	0-90	21.11
	Vegetable	17	7(41.18)	0-80	10.88	0-70	11.47
	Fallow	10	5(50.0)	0-50	12.00	0-50	19.00
	Garlic	8	5(62.50)	0-100	19.38	0-100	28.75
Tillage frequency	Two times	18	10(55.56)	0-75	28.01	0-100	33.33
	Three times	13	9(69.23)	0-80	29.61	0-70	26.54
	Four times	40	13(32.50)	0-100	8.0	0-80	13.63

Associations of White Rot with Tillage Frequency

White rot disease intensity also varies based on the tillage frequencies implemented on farm lands (Table 4). The lowest disease incidence (8.0%) and severity (13.63%) was recorded on four times cultivated farm lands where as the highest disease incidence (29.61%) and severity (33.33%) was recorded on three and two times tillage fields respectively. This might be duo the sclerotia buried in depth and inability to horizontally spread of the fungus onto adjacent roots. This finding is line with (Crowe *et al.,* 1980), the horizontal spread of the inoculum is rapid in the zone of greatest root density and horizontal root extension 2-4 cm below the base of plants and is progressively slower at greater depths as root density decreased and roots grew predominantly vertically.

Conclusions

It was concluded that incidence and severity of white rot were affected by environmental factors and agronomic practices. The disease prevalence varies with the variations of cultivar grown, soil type, plant density, cropping pattern, previous crop grown, slops of the field and tillage frequencies practices implemented on the fields. Higher white rot incidence and severity were recorded on vertisol type and previously garlic sown fields. Thus by crop rotations and plant garlic on nitisol can reduced the disease intensity. In addition, the higher incidence and severity were recorded in densely populated fields than in sparsely and medium populated fields. Use of row spacing with reduced plant density per row is also reducing the colonizing of pathogen from infected plant to healthy plant. Also, higher disease intensity was recorded on fields previously garlic sown fields than other non-host crop sown fields. Thus, by applying a long-term rotation schedule and by avoiding continuously growing Allium crops with proper spacing can reducethe disease pressure of garlic white rot. In broadcast cropping system of garlic, crop density was higher than row planting and highest percentage of disease incidence and severity were recorded. In addition farms cultivated four times recorded lower disease severity regarding two and three time's tillage farms. This is because as the farms cultivated more and more times the sclerotia will bury in depth and exposed to external environmental conditions. Growers should cleaning equipment used carefully after finishing operations to reduce the spread ofsclerotia and which also uses to protect the introduction of the disease to uncontaminated growing areas. The survey revealed high occurrence and distribution of white rot in the study area and effective and feasible management options need to be developed.

References

Amin M, Tadele S and Selvaraj T (2014). White rot (SclerotiumcepivorumBerk)-an aggressive pest of onion and garlic in Ethiopia: An overview. J Agric Biotech Sustain Dev., 6 (1): 6-15.

Ararsa L and Thangavel S (2013). Evaluation of ArbuscularMycorrhizal Fungi and Trichoderma Species for the Control of Onion White Rot (Sclerotiumcepivorum Berk) J. Plant Pathol. Microbiol. 4: 159.

Banks E and Edgington LV (1989).Effect of Integrated control practices on the onion white rot pathogen in organic soil.Canada J. plantpathol. 11: 268-272.

Brix HD and Zinkernagel V (1992). Screening for resistance of Allium species to Sclerotiumcepivorum with special reference to non-stimulator resistance. Plant pathol. 41: 308-316.

Coley-Smith JR (1987). Sclerotium cepivorum Berk. In European Handbook of plant Diseases, (eds I M. Smith, J. Dunez D. H., Phillips R. A. Lelliot and S. A Archer) Blackwell Scientific publications, 446-447.

Coley-Smith JR (1990). White rot disease of Allium: problems of soil-borne disease in microcosm. Plant Pathol. 39: 214

Crowe FJ, Hall DH, Greathead AS and Baghott KG (1980). Inoculum density of Sclerotium cepivorum and the incidence of white rot of onion and garlic. Phytopathology, 70: 64-69.

Diriba S (2016). Review of Management Strategies of Constraints in Garlic (Allium sativum L.) production. Journal of Agricultural Sciences, 11(3): 186-207.

Earnshaw D, Donald Mc and Boland GJ (2000).Interaction among isolates and mycelial compatibility groups of Sclerotium cepivorum and cultivars of onion (Allium cepa). J Plant Pathol., 22: 387-391.

Entwistle AR (1990). Allium white rot and its control. Soil Use Manage. 6: 201-209.

FAO (2006). Food security in Ethiopia, Agriculture and Consumer protection Department.

Getachew T and Asfaw Z (2000). Achievement in shallot and garlic research.Ethiopian Agricultural Research Organization, Addis Abeba, Ethiopia.

Larkin RP, Griffin TS and Honeycutt CW (2010). Rotation and cover crops effects on soil borne potato diseases, tuber yield and soil microbial communities. Plant Dis., 94: 1491-1502

Lemaga B, Kanzikwera R, Kakuhenzire R, Hakiza JJ and Manzi G (2001). The effect of crop rotation on bacterial wilt incidence and potato tuber yield. Afr. Crop Sci. J., 9: 257-266.

Manandhar HK, Timila RD, Sharma S, Joshi S, Manandhar S et al. (2016). A field guide for identification and scoring methods of diseases in the mountain crops of Nepal. NARC, LI-BIRD and BioversityInt P: 12.

Maude RB (2006). Onion Diseases. In: The Epidemiology of Plant Diseases, Cooke BM, Jones DG and Kaye B, (Eds.), Vol 19. Springer, USA.

Mengistu H (1994). Research on vegetables disease in Ethiopia. In: Herath E, Dessalegne L (eds.) Proceedings of the Second National Horticultural Workshop of Ethiopia, 1-3 December 1994. IAR, Addis Ababa, Ethiopia, pp. 209-215.

Najda L, Błaszczyk K, Winiarczyk J and Dyduch D (2016).Tchórzewska, Comparative studies of nutritional and health-enhancing properties in the “garlic-like” plant Allium ampeloprasum var. Ampeloprasum (GHG-L) and A. Sativum, Science Horticulture. 247–255.

Narayanasany P (2013). Biological management of diseases of crops; In integration of Biological control Strategies with crop disease management systems 1:364.

Porter IJ and Merriman PR (1983).Effects of solarization of soil on nematode and fungal pathogens at two sites in Victoria. Soil Biol. Biochem. 15: 39-44.

Prados-LigeroAM, Bascom-Fernandez J, Calvet-pinos C, Corpas-Harvias C, Ruiz AL, Melero-vara JM, MJBU (2002). Effect of different soil and clove treatments in the control of white rot of onion. J. Appl. Biol. 140: 247-253.

Rabinowitch C (2002). Allium Crop Science Recent Advance, CABI Publisher.529 pp.

Schwartz H and Mohan SK (2008). Compendium of Onion and Garlic Diseases and Pests, Second Edition. APS Press: 22-25.

Scott MR (1956). Studies of the biology of Sclerotium cepivorum Berk II. The spread of white rot from plant to plant. Ann. Appl. Biol. 44: 584-589.

Tamire Zewde, Chemeda Fininsa and Sakhuja KP (2007). Management of white rot (Sclerotium cepivorum) of garlic using fungicides in Ethiopia.Department of Plant Sciences. 26: 856–866.

Tindall HD (1983) Vegetables in the Tropics. Macmillan Press Ltd., London, 734 p.https://doi.org/ 10.1007/ 978-1-349-17223-8.

Wheeler BE (1969). An introduction to plant diseases. John Willey and Sons, Ltd., UK Pp. 301.

Wright PJ, Fallon RE and Hedderley D (2015). Different vegetable crop rotations affect soil microbial communities and soil borbe diseases of potato and onion: literature review and long-term field evaluation. New Zealand J. Crop Hortic. Sci., 43: 85-110.

Zenebu Shewakena, Negash Hailu and Bizzuhaman Desta (2020). Assessment on Incidence and Severity of White Rote Associated with Agronomic Practice and Environmental Factors at North Shewa, Central Highlands of Ethiopia. Int. J. African and Asian Studies, 62: 8-12.

Zeray S (2011). Distribution and Management of Garlic White rot in Northern Ethiopia: Distribution, Significance and Management of Garlic White Rot in Northern Ethiopia, Ambo University, Ambo Ethiopia.

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