Evaluation of garlic accessions for their yield, yield components, and white root rot (*Sclerotium cepivorum* Berk*)* in the southern zone of Tigray, Ethiopia

ABSTRACT

The objective of the study was to evaluate different local garlic accessions for their yield and disease tolerance to our location. The experiment was conducted at Zata and Ayba in 2015 cropping seasons. It was laid out in Randomized complete block design with three replications. The treatments were composed of 6 accessions and 2 nationally released varieties. The result of the experiment indicated mean yield, days to maturity, height, leaf number/plant, number of cloves/bulb, the width of the bulb, length of bulb and number of infected bulbs showed significant difference at both locations. The highest bulb yield was recorded from accession 07 (70.64 t/ha at Zata and 49.41 t/ha at Ayba) and tsedey variety (70.42 t/ha at Zata and 48.93 t/ha at Ayba) at both locations while, the lowest one was recorded from accession 08 (32.48 t/ha at Zata and 22.72 t/ha at Ayba), Beshoftu nech variety (38.13 t/ha at Zata and and 26.36 t/ha at Ayba) and 03 (38.92 t/ha at Zata and 27.23 t/ha at Ayba). The overall result indicates that Accession 07 showed that the highest yield and tolerance to the common disease of white root rot. So, it is promising to endorse Accession 07 in the southern zone of tigray and other similar agro ecology.

Keywords: *Garlic, accessions, white rot root, yield,*

1. INTRODUCTION

Garlic (*Allium sativum* L.) belongs to the family Alliaceae and is the second most widely used Allium next to onion [1]. It is believed to be originated in central Asia so called Kazakhstan [2]. Garlic has a high nutritive value as a rich source of minerals, carbohydrates, proteins, and vitamins. It also contains numerous bioactive molecules such as organic sulphur-containing (S-compounds) compounds and phenolic compounds [3, 4, 5]. Garlic is used for many conditions related to the heart and blood system [6].

In Ethiopia the Alliums group (onion, garlic, and shallot) are important bulb crops produced by small and commercial growers. Garlic is one of the important vegetable crops in Ethiopia for local market and export [7]. It is also the most ancient cultivated herbs and vegetative propagated by cloves and widely cultivated spice crops used for food as well as medicinal purposes. Economic significance of garlic in Ethiopia is quite considerable; it is grown as spice and used for flavoring local dishes, and contributes to the national economy as export commodity. It is mainly used for flavoring and seasoning vegetables in different dishes. It is used as ingredient of local stew 'wot' and has also a tremendous use in the formulation of local medicines [8]. Garlic is produced mainly in the mid and high lands of the country and the bulk of garlic for domestic market is produced in homestead gardens of subsistence farmers and produced mainly as cash [9]. Garlic is widely cultivated around home gardens, but nowadays, its production is practiced in some large farms [10].

In Ethiopia, the area coverage of garlic during the 2018/19 main cropping season was 21,754.49 ha and total production was about 1,957,400.45 tones with an average productivity of 88.98 t/ha. However, in Tigray region the area coverage was 1002.67 ha and total production of 7304.167 tones with an average productivity of 88.98 t/ha [11].

As compared to world production, the production and productivity of garlic is very low, which is due to many biotic (White Root Rot) and abiotic (lack of improved varieties, poor agronomic management practices and lack of irrigation facilities) bottlenecks [12, 13]. The selection of the cultivar should take into consideration several different factors and characteristics, some of which include the adaptability of the cultivar to the climate of the growing area, the market demand of the particular cultivar and the resistance or tolerance of the cultivar to various pests [14]. Inappropriate variety use in different agro ecology is one of the primary issues which significantly affect garlic phenotype, growth, yield, and nutritional quality [15]. Fungal diseases are the most important limitation for garlic production rate and its productivity. In fungal diseases, Sclerotium cepivorum is caused by white rot and it a very dangerous disease of garlic production throughout the world including Ethiopia [16]. In Ethiopia, compared to any other kind of vegetable diseases sustenance on garlic is the most pressing problem and it is very dangerous to rectify [17]. The region Northern Shewa in Ethiopia, white rot incidence had destroys the farmer's field was delineate at the rate ranging from 37.28 to 42%. The total cultivation loss had been found in the range of 20.7% to 53.4% [18].

In Tigray region garlic is grown in semi-arid areas with a low annual rainfall that varies greatly in space and time in terms of its amount and distribution. It is also produced in a large amount of land in the high lands of the southern zone of Tigray. However, the yield recorded in the area under the farmer's field is very low as compare to the other garlic production areas in the country. The main reasons for low productivities are lack of adaptable and high yielder varieties, disease and pest problems like white root rot. Even if the area is very suitable and the crop is very important commercially, farmer's income generation from garlic and productivity is still unsatisfactory. There are no any research efforts made in relation to evaluation of garlic varieties for their yield and disease resistance in study area. Almost all garlic producer farmers in the southern zone of Tigray have used a diversity of local garlic landraces as planting material. Collecting those local accessions and evaluating will result in selecting a high-performance variety for the area. Hence, the objective of this study was to identify adaptable, high yielding and diseases tolerant garlic accessions for study area.

2. MATERIALS AND METHODS

2.1. Description of the study area

The research was conducted in Southern Zone of Tigray, specifically in Zata and Ayba in 2015 cropping season. The altitude of Ayba is 2350 masl, with annual average rainfall of 912 mms and means daily temperature ranging between 9-23 ºC. It is located at longitude of 39°34'00.0"E and latitude of 12°52'60.0"N. The rainfall is bi-modal with the belg rain (short rains) occurring in March to May and the meher (main season) rains lasting from June to September [19]. Zata is located at longitude of 39º, 10.37', 0.17" E and latitude of 12º, 18.19', 0.304" N. Its altitude is 2,387 masl. The annual rainfall varies from 450 mm to 800 mm during keremt and 18mm to 250mm during Belg season. The mean annual temperature of the study area is 22ºc with minimum and maximum temperature of 6ºc and 30ºc respectively [20] (Fig.1).

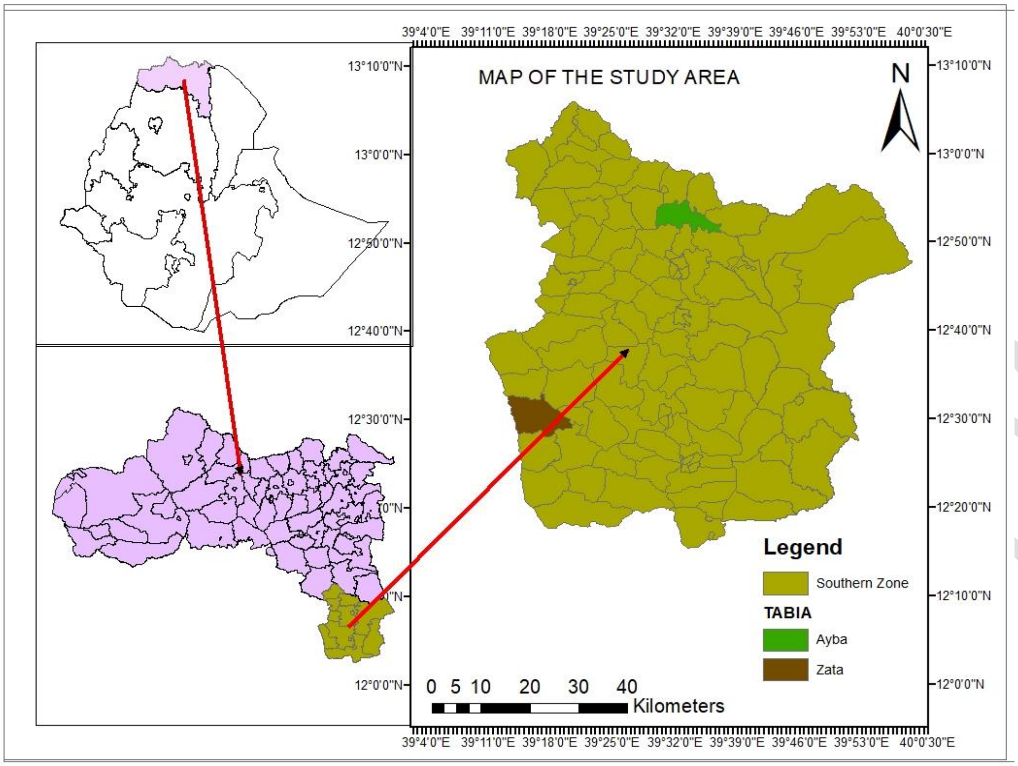

Fig 1. Map of the study area

2.2. Treatments and Experimental Design

The experiment was laid out in randomized complete block design (RCBD) design with three replications in a Plot size of 2 m x 1.5 m (3 m^2) with spacing of 1m between blocks and 0.5m between plots. The treatments were composed of six accessions and two nationally released varieties. Five rows per plot with distance between rows and plant 20 cm × 10 cm were employed. All treatments were assigned randomly to the experimental plots. The experimental field was prepared following the conventional tillage practice using oxen plow. Cloves of medium sized (2 -3 g) were planted by. Fertilizers were applied according to the national recommendation at the rate of 200 kg di ammonium phosphate at planting and 150 kg urea: 75 kg of urea at time of planting and the other 75 kg at after one month of planting [21]. Hand weeding was done every 15 days interval.

2.3. Data Collection

Data were recorded on plant height, leave number per plant, number of cloves per bulb and bulb width, from a sample of ten representative plants while days to maturity and bulb yields were collected on plot base. Also, disease data were collected by scale (1 to 5).

2.4. Data analysis

Data were analyzed using SAS Version 9.1 and parameters with significant differences were subjected to mean separation using LSD (5%)

3. RESULTS AND DISCUSSION

3.1. Growth parameters

3.1.1. <u>Days to maturity</u>

Days to maturity of accessions showed a highly significant difference (p<0.001, 0.001) at Zata and Ayba. Accessions 01, 08, 07 and 02 had the longest maturity days at both locations while accession 03 and 05 had the shortest maturity days at both locations (Table 1). Among the tested garlic accessions collected from different parts of southern tigray, days to emergence have been highly influenced by garlic accessions, due to the presence of real genetic variability which is paramount important for future garlic varietal breeding [22]. The current study aggress with the finding of [23] who reported that Kurftu (8 Days after Planting) and Holleta (8.51 Days after planting) were the earliest varieties, followed by variety Chafe (15 Days after planting), while Tsedey 92 (18.33 Days after planting) and local cultivar (18.01 Days after Planting) was the latest variety.

3.1.2. Plant height

The height of accessions showed a significant difference (p<0.059, 0.012) at both locations. Accessions 06, 05 and 03 had the highest height at both locations with a value of 60.07 cm, 57.17 cm and 56.13 cm at Zata and 65.13 cm, 64.43 cm and 62.43 cm at Ayba respectively. Whereas, accession 01 (51.67 cm), 02 (52.3 cm) and 04 (51.63 cm) at zata and accession 08 (57.47 cm), 01 (57.77 cm), 07 (58.73 cm) and 04 (58.74 cm) at Ayba had the lowest plant height (Table 1). The difference of accessions for plant height was due to genetic difference [24]. This finding was in line with the findings of [25] who reported significant variation for plant height due to the difference between genotypes.

3.1.3. Leaf number

The highest number of leaves was verified from accessions 6 (9.93), 5 (9.17) and 3 (9.17) at Zata while the lowest one was recorded from accessions 1 (8.27) and 2 (8.23). Similarly, at Ayba location the highest number of leaves was documented from accessions 6 (9), 7 (8.63), 8 (8.33) and 3 (8.33) while the lost one was noted from accessions 1 (8.10), 5 (7.77) and 4 (7.93) (table 1). The variation observed in the number of leaves per plant indicated the presence of genetic variation among the accessions [23]. A similar study reported that variety Kuriftu has been observed as one of the higher leaf-producing varieties [9]. In line with the current report, smaller number of leaves per plant was recorded from variety Chafe (7.47).

Table 1. Mean of days to maturity, plant height (cm) and leaf number of garlic accessions in the southern zone of Tigray, Ethiopia

Treatment name	Acc no	Ayba			Zata		
		DM	PH (cm)	LN	DM	PH (cm)	LN
Beshiftu nech	1	151.00a	57.77cd	8.10b	146.00a	51.67dc	8.27c
Tseday	2	149.67a	62.25abc	8.17ab	145.00a	52.30cd	8.23c
Bora 1 month	3	136.33d	62.43ab	8.33ab	131.33d	56.13abc	9.17ab
Bora 2 month	4	146.67b	58.74bcd	7.93b	141.67b	51.63dc	8.53bc
Around bora 1 month	5	134.67d	64.43a	7.77b	129.67d	57.17ab	9.17ab
Around bora 2 month	6	140.00c	65.13a	9.00a	135.00c	60.07a	9.93a
Brki 1 month	7	150.00a	58.73bcd	8.63ab	145.00a	53.33bdc	8.50bc
Brki 2 month	8	150.67a	57.47d	8.33ab	146.00a	53.87bdc	8.50bc
LSD (5%)		2.77	4.62	0.89	2.72	4.15	0.78
CV (%)		1.0926	4.33	6.11	1.11	4.34	5.06

NB: - Acc no = Accession number, DM = Days to maturity, PH = Plant height, and LN= Leaf number

3.2. Yield Related Parameters

3.2.1. Clove number per bulb

Clove number per bulb showed a significant difference at Zata at (P<0.05). All accessions except accession 06 and 05 did not show a significant difference. Accession 06 had the highest number of cloves (18.30) but, accession 05 had the lowest number of cloves per bulb (10.67) at Zata. On the other hand, clove numbers per bulb at Ayba showed a non-significant difference (p<0.058) (Table 2). This finding matches with [26] who states that, highest number of cloves per bulb was recorded from the local variety (20.45) followed by Kuriftu (16.68). Tseday 92 scored significantly lowest number of cloves per bulb but the study conducted by Galgaye and Deresa, 2023, shows that there was no significant difference among varieties Tsedey 92, Chafe, Kuriftu, and Holleta in clove number per bulb. The variation in clove number per bulb among the accessions was due to their heredity characters [27].

3.2.2. Bulb width

Garlic accession 02, 06 and 01 grown at Zata location had the highest bulb width with a mean value of 4.70 cm, 4.50 cm and 4.38 cm respectively. However, accession 05 had the lowest bulb width (3.57 cm). Similarly, Garlic accession 02, 06 and 01 grown at Ayba location recorded highest bulb width with a mean value of 3.37 cm, 3.25 cm and 3.15 cm respectively. But, the lowest one was obtained from accession 5 (2.55 cm) (Table 2). This was in line with the finding of [24] in which their mean values revealed that the maximum bulb diameter was recorded from Local (20.03cm) followed by Kuriftu (19.08cm) while the lowest bulb diameter (16.42cm) was recorded from the Bushoftu variety.

3.2.3. Bulb yield

The yield of accessions at both locations showed a significant difference (p<0.0001, 0.0001). The highest yield was recorded from accession 07 (70.64 t/ha at Zata and 49.41 t/ha at Ayba) and tsedey variety (70.42 t/ha at Zata and 48.93 t/ha at Ayba) followed by accession 06 (59.85 t/ha at Zata and 41.22 t/ha at Ayba) and 04 (51.94 t/ha at Zata and 36.35 t/ha at Ayba) at both locations. However, accession 08 (32.48 t/ha at Zata and 22.72 t/ha at Ayba), Beshoftu nech variety (38.13 t/ha at Zata and and 26.36 t/ha at Ayba) and 03 (38.92 t/ha at Zata and 27.23 t/ha at Ayba) resulted the lowest yield (Table 2). This result indicated that the local accession is superior to the nationally released varieties. The variation in yield of the varieties might be due to the genetic factors of the varieties as well as might be due to the differences in the fertility level of the field [27]. The current study matches with the findings of [26] who observes significantly highest fresh bulb weight (16.56 t/ha) was recorded from the local variety followed by Kuriftu (11.78 t/ha).

Table 2. Mean of clove number per bulb, bulb width and bulb yield of garlic accessions in southern zone of Tigray, Ethiopia

		Ayba			Zata		
Treatment name	**Acc no**	**Cl no**	**BW (cm)**	**BY (t/ha)**	**Cl no**	**BW (cm)**	**BY (t/ha)**
Beshiftu nech	1	8.9	3.15ab	26.36e	12.58ab	4.38a	38.13d
Tseday	2	10.85	3.37a	48.93a	15.34ab	4.70a	70.42a
Bora 1 month	3	11.05	2.79bc	27.23de	15.62ab	4.09ab	38.92d
Bora 2 month	4	11.35	3.02abc	36.35bc	16.04ab	4.23ab	51.94bc
Around bora 1 month	5	7.55	2.55c	32.66cd	10.67b	3.57b	48.65c
Around bora 2 month	6	12.95	3.25ab	41.22b	18.30a	4.50a	59.85b
Brki 1 month	7	9.93	2.80abc	49.41a	12.93ab	3.89ab	70.64a
Brki 2 month	8	10.95	2.86abc	22.72e	15.47ab	3.98ab	32.48d
LSD (5%)		7.11^{ns}	0.78	5.69	7.53	0.8	8.83
CV (%)		9.42	5.14	9.12	7.42	8.3	9.81

NB: - Acc no = Accession number, Cl no = Clove number, BW = Bulb width and BY = Bulb yield

3.3. Incidence of White root rot on garlic bulb

The number of infected bulbs with White Root Rot showed a significant difference ($p<0.045$, $p< 0.04$,) at both locations. Accession 04 (3%) followed by accession 03 (2 %), 01 (1.67 %) and 02 (1.67 %) showed the highest number of infected bulbs by White root rot and Accession 07 (0.00 %), 06 (0.33 %), 08 (0.67 %) and 05 (0.67 %) showed the lowest number of infected bulbs by White root rot at Zata. Similarly, at Ayba, accession 03 (31.33 %), 06 (30.67 %) followed by 02 (28.67 %) and 1 (26.67 %) showed the highest number of infected bulbs by White root rot. Though, Accession 05 (14.67 %), 08 (16.67 %), 07 (17.67 %) and 4 (19.33 %) showed the lowest infected bulbs at Ayba. This indicates the local landraces had the best tolerance than the improved varieties (Accession 01 and 02) (fig 2.). The study was aligned with the study of [28] who revealed that the highest white rot disease was recorded from BARI Rashun-3 variety (89.33%) while the lowest one was recorded from local Indian variety (60%).

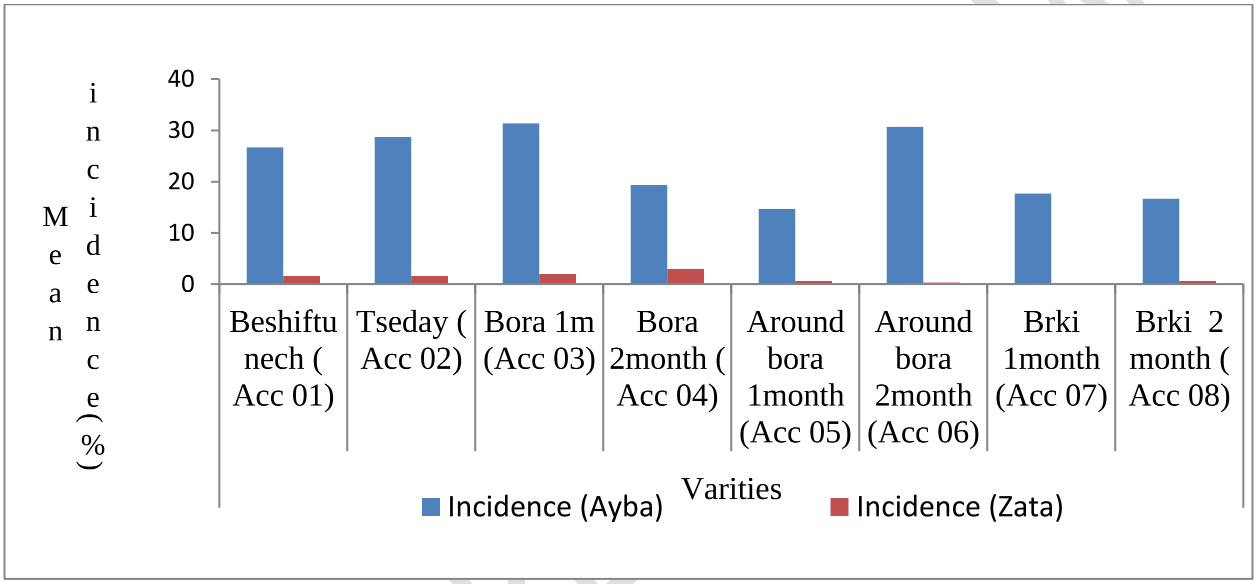

Fig.2. Number of infected garlic bulbs by white root rots in the southern zone of Tigray, Ethiopia

4. CONCLUSION

In Ethiopia the Alliums group (onion, garlic, and shallot) are important bulb crops produced by small and commercial growers. Garlic is produced in a large amount of land in the high lands of the southern zone of Tigray. However, the yield recorded in the area under the farmer's field is very low as compare to the other garlic production areas in the country due to lack of adaptable and high yielder varieties and disease problem like White Root Rot. The result of the experiment indicated days to maturity, plant height, leaf number per plant, bulb width, bulb yield, and number of infected bulbs showed significant difference at both locations. The highest bulb yield was recorded from accession 07 (70.64 t/ha at Zata and 49.41 t/ha at Ayba) and tsedey variety (70.42t/ha at Zata and 48.93 t/ha at Ayba) followed by accession 06 (59.85 t/ha at Zata and 41.22 t/ha at Ayba) and 04 (51.94 t/ha at Zata and 36.35 t/ha at Ayba) at both locations while, the lowest one was recorded from accession 08 (32.48 t/ha at Zata and 22.72 t/ha at Ayba), Beshoftu nech variety (38.13 t/ha at Zata and and 26.36 t/ha at Ayba) and 03 (38.92 t/ha at Zata and 27.23 t/ha at Ayba). Accession 04 (3%) followed by accession 03 (2 %), 01 (1.67 %) and 02 (1.67 %) showed the highest number of infected bulbs by White Root Rot and Accession 07 (0.00 %), 06 (0.33 %), 08 (0.67 %) and 05 (0.67 %) showed the lowest number of infected bulbs by White Root Rot at Zata. Similarly, at Ayba, accession 03 (31.33 %), 06 (30.67 %) followed by 02 (28.67 %) and 1 (26.67 %) showed the highest number of infected bulbs by White Root Rot. Though, Accession 05 (14.67 %), 08 (16.67 %), 07 (17.67 %) and 4 (19.33 %) showed the lowest infected bulbs at Ayba. The overall result indicates that accession 07 (70.64 t/ha at Zata and 49.41 t/ha at Ayba) showed that the highest yield and highest tolerance to the common disease of white root rot. Accordingly, it is encouraging to promote accession 07 in the southern zone of Tigray and other similar agro ecology.

REFERENCES

1. Yadav RN, Bairwa HL, Gurjar MK. Response of garlic (Allium sativum L.) to organic manures and fertilizers. International Journal of Current Microbiology and Applied Sciences. 2017;6(10):4860-7.
2. So TK, Abdou R, Sani IS, Toudou AK, Bakasso Y. Garlic (Allium sativum L.): Overview on its biology and genetic markers available for the analysis of its diversity in West Africa. Asian Journal of Biochemistry, Genetics and Molecular Biology. 2021 Mar 23;7(3):1-0.
3. Martins N, Petropoulos S, Ferreira IC. Chemical composition and bioactive compounds of garlic (Allium sativum L.) as affected by pre-and post-harvest conditions: A review. Food chemistry. 2016 Nov 15;211:41-50.
4. Moutia M, Habti N, Badou A. In vitro and in vivo immunomodulator activities of Allium sativum L. Evidence-Based Complementary and Alternative Medicine. 2018;2018(1):4984659.
5. D'Archivio AA, Foschi M, Aloia R, Maggi MA, Rossi L, Ruggieri F. Geographical discrimination of red garlic (Allium sativum L.) produced in Italy by means of multivariate statistical analysis of ICP-OES data. Food chemistry. 2019 Mar 1;275:333-8.
6. Singh DK, Lallan Singh LS, Pandey UB. Nutritional and medicinal values of onion and garlic.2004.
7. Silva AR, Cecon PR, Dias CT, Puiatti M, Finger FL, Carneiro AP. Morphological phenotypic dispersion of garlic cultivars by cluster analysis and multidimensional scaling. Scientia Agricola. 2014;71:38-43.
8. Mulatu A, Tesfaye B, Getachew E. Growth and bulb yield garlic varieties affected by nitrogen and phosphorus application at Mesqan Woreda, South Central Ethiopia. Sky Journal of Agricultural Research. 2014 Dec;3(11):249-55.
9. Atinafu G, Mengistu FG, Tewolde FT, Asfaw Y, Tabor G, Fekadu D. Morphological characterization and evaluation of garlic (Allium sativum L.) accessions collected from northern highlands of Ethiopia. Results of Crop Improvement and Management Research for. 2022.
10. Ayed C, Mezghani N, Rhimi A, AL Mohandes Dridi B. Morphological evaluation of Tunisian garlic (Allium sativum L.) landraces for growth and yield traits. Journal of Horticulture and Postharvest Research. 2019 Mar 1;2(1):43-52.
11. CSA (Central Statistical Agency). The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey, 2018/19 Volume I Report on area and production of major crops Addis Ababa, April, 2019
12. DZARC .Garlic production management. Debrezeit Agricultural Research Center, Leaflet (Amharic Version), Debrezeit, Ethiopia. 2006.
13. Getu S. Assessment of garlic production practices and effect of NP fertilizer rate on bulb yield and yield components in Yilmana Densa district (Doctoral dissertation, Bahir Dar University). 2015.
14. Kaur B, Singh K, Chawala N. Evaluation of Garlic Germplasm for Yield Attributes and Quality Characters from Niche Area of District Jalandhar, India. Int. J. Curr. Microbiol. App. Sci. 2020;9(4):706-12
15. Gebre Garmame Galgaye and Hachalu Kinfu Deresa (2023). Effect of garlic genotypes (Allium sativum L.) on phenotype, growth, yield-related attributes, and nutritional quality at Bule Hora agro-ecology. Heliyon 9, e16317.
16. Spooner BM, Roberts PJ. Richard William George Dennis, 1910–2003. Mycologia. 2004 Jan 1;96(1):187-9.
17. Amin M, Tadele S, Selvaraj T. White rot (Sclerotium cepivorum-Berk) an aggressive pest of onion and garlic in Ethiopia: An overview. Journal of Agricultural Biotechnology and Sustainable Development. 2014 Jun 25;6(1):6-15.
18. Zewide T, Fininsa C, Sakhuja PK. Management of white rot (Sclerotium cepivorum) of garlic using fungicides in Ethiopia. Crop protection. 2007 Jun 1;26(6):856-66.
19. Girmay T, Girmay G, Alem G, Abrhaley G, Yemane G, Hagos T. Participatory rural appraisal report: Alaje Woreda, Tigray region. Cascape Working Paper, 2.6. 2014:1.
20. Ofla Woreda Agriculture and Rural Development Office. ofla, Ethiopia; 2019.
21. Ethiopia Agricultural Research Organization (EARO). Directory of released crop varieties and their recommended cultural practices. Addis Abeba, Ethiopia; 2004.
22. A. Tesfaye, D.F. Mijena, H. Zeleke, G. Tabor, Genetic variability and character association for bulb yield and yield related traits in garlic in Ethiopia, Afr. CropSci. J. 29 (2) (2021) 293–308.

23. Galgaye GG, Deresa HK. Effect of garlic genotypes (Allium sativum L.) on phenotype, growth, yield-related attributes, and nutritional quality at Bule Hora agro-ecology. Heliyon. 2023 Jun 1;9(6).
24. Yeshiwas Y, Negash B, Walle T, Gelaye Y, Melke A, Yissa K. Collection and characterization of garlic (Allium sativm L.) germplasm for growth and bulb yield at Debre Markos, Ethiopia. Journal of Horticulture and Forestry. 2018 Mar 31;10(3):17-26.
25. Alam MS, Rahim MA, Simon W (2010). Performance evaluation of garlic germplasm under dry land condition. J. Agrofor. Environ.3(2):43-45.
26. Ayalew A, Tadesse D, Medhin ZG, Fantaw S. Evaluation of garlic (Allium sativum L.) varieties for bulb yield and growth at dabat, northwestern Ethiopia. Open Access Library Journal. 2015 Jan 1;2(1):1-5.
27. Ibrahim M, Shafiullah MI, Shah FA, Abid SR, Haq IU. Comparison of different garlic (Allium Sativum) varieties for yield and yield components grown at agriculture research station, Buner. Int J Environ Sci Nat Res. 2018;13(5):555873.
28. Akter UH, Begum F, Islam MR, Khatun MR, Islam MM. Screening of Selected Garlic Varieties Against White Rot Disease Caused by Sclerotium cepivorum at Dhaka City of Bangladesh. American Journal of Plant Biology. 2021;6(3):53-9.