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Performance of garlic cultivars under rain-fed cultivation practice at South Gondar Zone, Ethiopia

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Garlic (*Allium sativum L.*) is an important edible bulbous crop with unique culinary and medicinal purposes. It is a major cash crop widely cultivated in Libokemkem and other districts of South Gondar zone of Amhara Region in Ethiopia. However, productivity of garlic in Ethiopia in general and in South Gondar Zone in particular is very low largely due to the use of unimproved local cultivars and traditional cultural practices. Five different improved cultivars of garlic were then evaluated for yield and yield components under rain-fed production practice. This acclimatization and performance evaluation at three different locations (Angot, Ginaza and Woreta) was laid in randomized complete block design with three replications. Cultivar Adiszemene local (55.44, 39.82 and 22.28 quintal per hectare (q/ha)) produced consistently high dry bulb yield at the three locations. Cultivar Chefe was found to be the lowest yielding at Angot (16.07 q/ha) and Ginaza (22.56 q/ha), whereas cultivars Kuriftu (11.92 q/ha) and Tsedey (10.06 q/ha) were the lowest yielding at Woreta indicating profound effect of environment on yield. Overall result revealed that statistically significant (P<0.05) high dry bulb yield (39.18 q/ha) was recorded in cultivar Adizemene local, followed by cultivar Holleta (31.32 q/ha). These cultivars with consistent high performance and wide adaptability would then be demonstrated and popularized for wide spread cultivation.

Key words: Acclimatization, allicin, bulb, environment, medicine, spice.

INTRODUCTION

Garlic (*Allium sativum L.*) is an important edible bulbous crop belonging to the family Alliaceae along with onion, shallot, leek and chives. It is the second most widely cultivated Allium after onion and has been used throughout history for culinary and medicinal purposes (Pandey, 2012). Garlic has higher nutritive value than other bulbs crops (Abou El-Magd et.al, 2012). Keeping in view of its medicinal value, especially Allicin of garlic which has antibacterial properties (Al-Otayk et. al, 2009 and Sterling and Eagling, 1997), garlic is widely used in all households throughout the year. According to Amagase et al (2001) and Iciek et al (2009), the unique flavor and health-promoting functions of garlic are generally attributed to its rich content of sulfur-containing compounds, that is, alliin, g-glutamylcysteine, and their derivatives. Processing a fresh and intact garlic bulb by crushing, grinding, or cutting induces the release of the vacuolar enzyme alliinase, which very quickly catalyzes

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allin to allicin. Allicin is a very unstable compound, soon rearranged and transformed into numerous lipid-soluble sulfur-containing by products, mostly diallyl disulfide (DADS) but also diallyl sulfide (DAS), diallyl trisulfide (DATS), allylmethyl trisulfide, and diallyl tetrasulfide (Iciek et.al, 2009). These compounds emit strong odors and are kept in garlic oil. Garlic is used in sauces, soups and for seasoning foods. The cloves are also pickled in vinegar. Garlic is rich in phosphorus, calcium and carbohydrates (Khan et al., 2018).

Garlic is grown worldwide in all temperate to subtropical and tropical hilly areas as an important spice and medicinal plant (Pandey, 2012). Clinically, garlic has been evaluated for lowering blood pressure, cholesterol, and glucose concentration, as well as for the prevention of arteriosclerosis and cancer (Tsai et al., 2012). It was further indicated that, epidemiologically, garlic consumption inversely correlates with the risk of oral, stomach, esophageal, colon, and prostate cancers. In addition, the biological activities of garlic, including antibacterial, antithrombotic, antioxidant, immuno-modulatory, and antidiabetic actions and modulation of drug metabolism, have been extensively investigated. Despite its various uses for flavouring food and treatment of health problems, garlic breeding has been hampered for the plants rarely produce seed and are propagated asexually by cloves or sometimes by top sets. Cultivar development for better yield and quality was therefore solely based on clone selection from variations due to mutation. According to Etoh and Simon (2002), only limited genetic variation can be introduced via mutations and it is very hard to make significant progress by mutation breeding alone. However, Khar et al (2011) and Senula and Keller (2000) reported that garlic exhibits a wide range of diversity in morphological, reproductive and bulb traits because of its apomictic nature which leads to the existence of extensive somatic mutations (Ata, 2005). It was further indicated by Jabbes et al. (2012) that garlic presents, in spite of its vegetative multiplication, a great diversity from agro-morphological and biochemical point of view (Abdoli et al., 2009; Burba and Gomez Riera, 1997; Hong, 1999; Lallemand et al., 1997; Messiaen et al., 1993; Ovesna et al., 2007 and Stavelìkova, 2008.). This variability is required; in fact, researchers benefit from the wide diversity of garlic for the selection of best genotypes. The genetic diversity serves as a source of genotypes adapted to local conditions (Baghalian et al., 2005).

Ethiopia with diversified agro-ecological conditions is suitable for garlic production. South Gondar zone in Amhara region of Ethiopia is potentially endowed with favorable climatic and soil conditions for the cultivation of garlic both under rain fed and using irrigation. Garlic in this zone particularly in Libokemkem District is a major cash crop produced both under rain fed and irrigation in larger plots similar to field crops such as maize, rice and ‘tef’ (*Eragrostis tef*). Rain fed garlic in Libokemkem is usually planted from June to July and harvested in October and the plot is sown immediately with chick pea, whereas irrigated garlic is planted in November after harvesting, cereals such as ‘tef’ and maize produced in the rainy season from May to October.

The contribution of this sector towards ensuring engagement of large number of labor with the participation of female and youths could not be undermined since garlic production is a labor intensive job. Despite multifaceted uses, garlic suffers from several problems that caused low productivity and poor quality largely attributable to the use of unimproved local cultivars with poor productivity. Yeshiwas et al (2017) also indicated that lack of improved varieties and garlic rust is the major one among many contributing factors responsible for low production and productivity of garlic in Ethiopia. Moreover, due to repeated cultivation of similar cultivars for several years in specific plots, fungal contamination of planting materials and soil is observed in the vicinity of Libokemkem areas. Besides applying improved husbandry practices, it is therefore crucial to identify appropriate cultivar with high productivity and quality suitable to target environments. With an ultimate objective of supplying healthy planting materials of alternative cultivars, this trial was therefore undertaken to evaluate cultivars for acclimatization and performance studies at Fogera and Libokmekm districts in Northwestern Ethiopia.

MATERIALS AND METHODS

The experiment was conducted at three locations: two in Libokemkem District (Angot and Ginaza kebeles) and one in Fogera District (Woreta kebele) of south Gondar zone of Amhara Region in Ethiopia. Planting materials of released garlic cultivars, Viz., Chefe, Holleta, kuriftu and Tsedey were obtained from Debre Zeit Agricultural Research Centre while bulbs of Adiszemene local were bought from Adiszemene market. Cultivars were then laid in randomized complete block design with three replications in three locations namely, Woreta, Angot and Ginaza in South Gondar Region of northwestern Ethiopia.

Land was prepared to a fine tilth through repeated plowing the experimental plot. Ridges of 20 centimeter (cm) width and 25 cm height along with 40 cm furrow width were prepared. Cloves (bulb splits) were then planted at both sides of the ridge with 10 cm distance between plants.

The spacing used was therefore 40 cm furrow width, 20 cm distance between rows on the ridge and 10 cm between pants. Effective plot size was 4.8 m^2 (2.4m x 2m) and contained 160 plants on two meter long four ridges (8 rows).

Planting dates were June 19, 26 and 30, 2018 for garlic trials at Woreta, Angot and Ginaza, respectively. Depending on maturity time of cultivars, harvesting at these locations was accomplished from September 20 to October 15, 2018.

A mix of Nitrate Phosphate sulfur (NPS) (38:19:5) at the rate of 242 kg/ha and Urea (46%N) fertilizers at the rate of 100 kg/ha were applied. NPS fertilizer was applied once at planting while Urea was applied in two splits, the first at full emergence (10-15 days after planting) and the second at one and 1/2 months after planting. Hand weeding and cultivation (hoeing) was performed throughout the field evaluation period. Stand count, plant height and record for

Table 1. Mean dry yield, days to maturity and plant height of garlic cultivars at Angot Kebele in 2018 rainy season (June to September).

Cultivar	Yield (q/ha)	Yield per plant (g)	Days to maturity	Height (cm)
Adiszemene local	55.44	19.27	100.00	56.17
Holleta	42.74	18.52	103.67	57.43
Tsedey	40.88	16.63	110.00	56.83
Kuriftu	30.62	11.50	104.67	51.93
Chefe	16.07	6.32	95.00	50.80
LSD (0.05)	11.39	3.39	3.72	8.04
CV%	16.29	12.45	1.92	7.82

Table 2. Mean dry yield, days to maturity and plant height of garlic cultivars at Ginaza Kebele in 2018 rainy season (June to September).

Cultivar	Yield (q/ha)	Yield per plant (g)	Days to maturity	Height (cm)
Adiszemene local	39.82	17.18	98.00	41.60
Holleta	30.51	13.25	99.67	48.55
Tsedey	25.24	14.51	106.00	50.27
Kuriftu	24.71	12.81	106.00	51.38
Chefe	22.56	9.43	96.00	42.65
LSD(0.05)	7.17	2.07	2.57	3.35
CV%	13.37	8.18	1.35	3.79

disease incidence were made during the vegetative phase. Data were recorded on maturity date, bulb size, dry yield per plant and plot. Data were subjected to analysis of variance and least significance difference (LSD) was used to compare treatment means when there was statistically significant difference ($P<0.05$)

RESULTS AND DISCUSSION

Significant differences ($P<0.05$) among cultivars were recorded for dry bulb yield in quintals per hectare, yield per plant and days to maturity. Cultivars Adizemene local (55.44 q/ha) followed by Holleta (42.74 q/ha) and Tsedey (40.88 q/ha) gave the highest dry bulb yield in quintal per hectare at Angot kebele of Libokmkem District while Chefe (16.07 q/ha) was the lowest yielding cultivar. Similarly, field trials conducted by Omnarayan and Thakre (2018) to study the performance of different varieties on growth, yield and quality of Garlic (*Allium sativum* L.) under agro-climatic conditions of Allahabad revealed that best results were recorded on all the parameters in variety KS-2 followed by variety G-4 and the minimum was recorded with Agrifound White. Significant variation among the genotypes for total yield and marketable yield was also reported by Aslam et al. (2016).

Cultivar Chefe was early in maturity taking only 95 days at Angot. Besides, Holleta (57.43 cm) was found to be the tallest cultivar at Angot, though differences in height among cultivars were not statistically significant (Table 1). As compared with other cultivars, Adizemene local and Holleta gave the highest yield in quintal per hectare at Ginaza kebele (Table 2). Ayalew et al. (2015) also obtained significantly highest yield from the local variety at Dabat District of Northwestern Ethiopia further reflecting that varieties released for certain areas may not suit other areas. However, the lowest yielding cultivars were Tsedey (10.06 q/ha) and Kuriftu (11.92 q/ha) at Woreta, and Chefe (22.56 q/ha) at Ginaza kebeles. As compared to other cultivars, Adiszemene local and Chefe (94 days) were early maturing at Woreta. Furthermore, Adiszemene local (43.63 cm) was shorter in height than other cultivars at Woreta, whereas Chefe (42.65 cm) and Adiszemene local (41.60 cm) were the shortest cultivars at Ginza (Tables 2 and 3). On the other hand, trials conducted during dry periods under irrigation at Dabat District, Northwestern Ethiopia indicated that BishoftuNech was early maturing variety (135 days) followed by Kuriftu (143 days), whereas MM-98 matured late at 176 days after planting (Ayalew et al., 2015). This could be attributable to differences in growing conditions including agro-ecology (temperature, altitude etc), soil and cultural practices. Furthermore, Khatun et al (2014) showed significant difference among varieties in plant height, weight of bulb per plant and number of bulb per square meter which might have increased yield significantly. It was also indicated that the highest yield (8.11and 8.04 ton per hectare during two successive years) was obtained from BARI Roshun 2 while the

Table 3. Mean dry yield, days to maturity and plant height of garlic cultivars at Woreta Kebele in 2018 rainy season (June to September).

Cultivar	Yield (q/ha)	Yield per plant (g)	Days to maturity	Height (cm)
Adiszemene local	22.28	8.72	94.00	43.63
Holleta	20.72	9.20	110.00	51.26
Tsedey	10.06	6.31	112.00	46.18
Kuriftu	11.92	7.96	114.33	47.53
Chefe	21.11	8.36	94.00	47.05
LSD(0.05)	8.3	2.8	3.87	3.95
CV%	25.59	18.32	1.96	4.45

Table 4. Mean dry yield, days to maturity and plant height of garlic cultivars in the three locations in 2018 rainy season (June to September).

Cultivar	Yield (q/ha)	Yield per plant (g)	Days to maturity	Height (cm)
Adiszemene local	39.18	15.06	97.33	47.13
Holleta	31.32	13.65	104.44	52.41
Tsedey	25.39	12.48	109.33	51.09
Kuriftu	22.42	10.76	108.33	50.28
Chefe	19.81	8.04	95.00	46.83
LSD (0.05)	4.56	1.57	1.72	2.88
CV%	17.11	13.56	1.73	6.03

Location	Yield (q/ha)	Yield per plant (g)	Days to maturity	Height (cm)
Angot	37.15	14.45	102.67	54.63
Ginaza	28.51	13.43	101.13	46.89
Woreta	17.22	8.11	104.87	47.13
LSD(0.05)	3.54	1.22	1.33	2.23

lowest yield (6.38 and 5.50 ton per hectare during two successive years) was obtained from local variety. It was also reported in Onvegetables (2018) that out of nine garlic cultivars evaluated in Mount forest, Ontario, Thermadore performed the best but not significantly better than Messadore or Saba Gold. Knowing more about cultivar performance will allow one to make more viable decisions in the future when it comes to trying different cultivars for large scale commercial production.

Overall highest yield was obtained from Angot followed by Ginaza (Table 4) that could mainly be attributable to suitability of soil and environmental condition for the manifestation of genetic potential of different cultivars. The effect of different environmental factors on performance of garlic cultivars was also emphasized by Khan et al. (2018). Raslan et al. (2015) also indicated that garlic yield and quality vary greatly with cultivar, location, soil type, agricultural methods and harvest date. According to Ennes (1990) varieties do not perform equally in all environments, but some tend to be close to the ideal than others. Likewise, Foreaker (2015) reported that different types of garlic were chosen for two separate growing seasons at Alaska. Indeed, cultivars response is therefore measured through interaction of genotypes and the environments.

Overall mean dry bulb yield from the three locations was significantly high in cultivar Adiszemene local followed by Holleta. Cultivars Chefe and Adiszemene local were early maturing and the shortest in height (Table 4). Height in centimeter was strongly correlated with yield at Angot (r=0.84) (Figures 1, 2 and 3). This is inconformity with the reports of Zakari et.al (2017) that the increase in plant heights, number of leaves and other positively correlated characters increased the amount of assimilates being produced and translocated to the sink which finally has effect on the yield. Insignificant correlation (-0.48 and 0.02) was also observed between height and yield at Ginaza and Woreta. According to Albuquerque et.al (2017), correlations among several quantitative parameters evaluated were verified using phenotypical correlation coefficients because most of them were significant (r>0.7). Bulb production is correlated with the vegetative growth (Adekpe et al., 2007). Garlic plants with well-developed vegetative

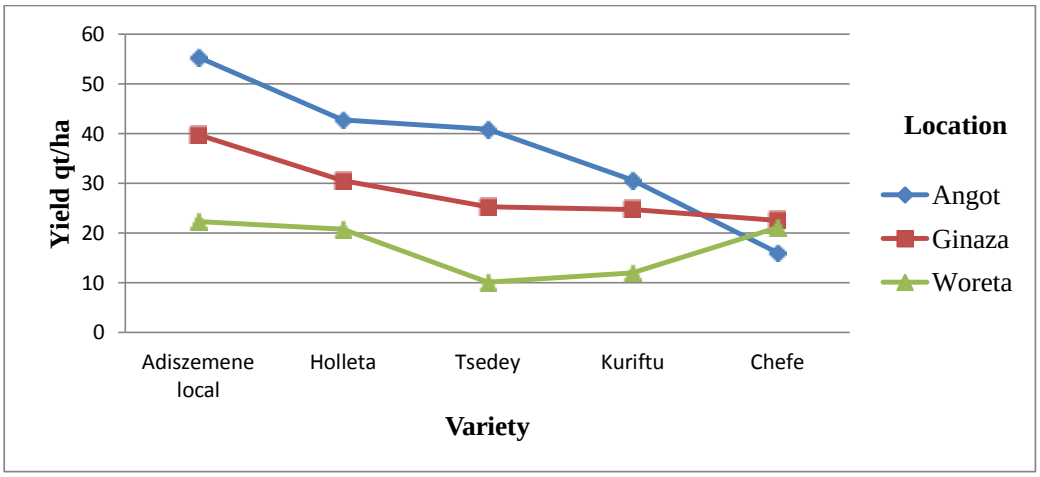

Figure 1. Yield in quintal per hectare of garlic cultivars at different locations, Ethiopia.

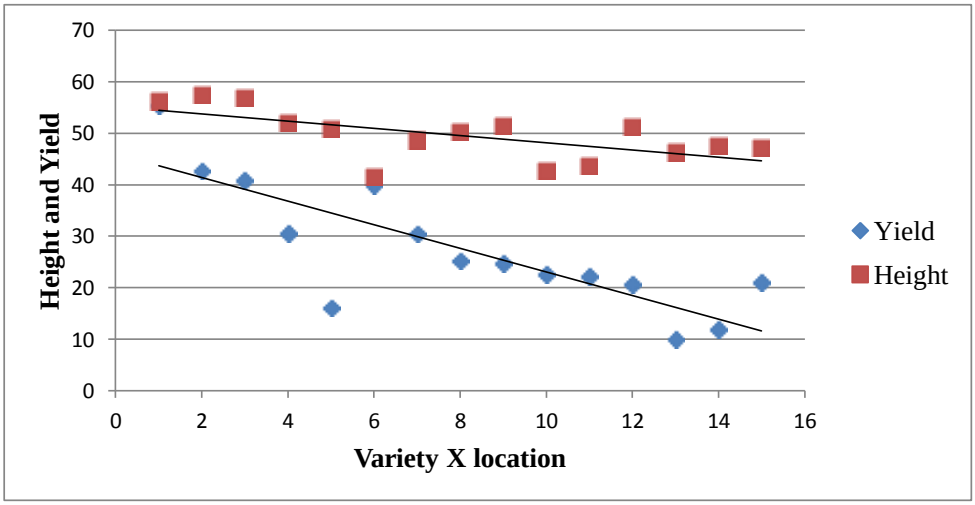

Figure 2. Correlation between height in cm and Garlic yield in qt/ha (r=0.52).

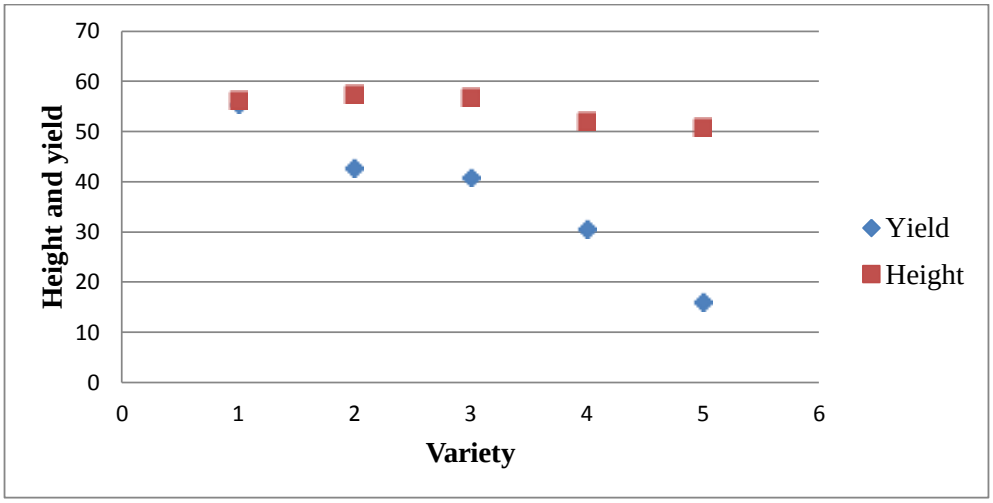

Figure 3. Correlation between height in cm and yield of Garlic in qt/ha at Angot, Ethiopia (r=0.84)

structures have effective source-drain systems for nutrient and photoassimilate translocation to the bulbs from the leaves and the pseudo-stems. This property results in a greater potential for the production of large bulbs (Mathew et al., 2011).

Conclusion and recommendations

Cultivars Chefe and Adiszemene local were early maturing, while Holleta was intermediate and Tsedey and Kuriftu were late maturing. On the other hand, Chefe was the lowest yielding and Adiszemene local was the highest yielding cultivar. Yield performance of cultivars at Kebele Angot was significantly higher as compared to the other two kebeles (locations) revealing variations in suitability of soil and environmental conditions for the cultivation of garlic. Plant height was strongly correlated with dry bulb yield at Angot which is the most appropriate location for garlic cultivation suggesting that plant height could be used as selection criterium in cultivar development of garlic. Overall performance revealed that cultivars Adiszemene local and Holleta were found to be the best yielding cultivars suitable for cultivation across locations. These cultivars can therefore be recommended for on farm demonstration to further verify performance of these cultivars with active participation of farmers, extension experts and development agents. Popularization of the cultivars and multiplication of healthy planting material for wide spread dissemination will therefore rely on feedback from demonstration and divulgation efforts.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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