

Full Length Research Paper

Assessment of small holder farmers garlic (*Allium sativum* L.) production practices under irrigated farming system in the Highlands of Ethiopia

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Garlic is a fundamental component of many dishes in Ethiopia. However, there is a low production of this crop in the Yilmana Densa district of Amhara Region (Ethiopia). Thus, a study was initiated in 2014/2015 to assess farmer's garlic production practices under an irrigated farming system in the Yilmana Densa district (Adet Zuria, Goshaye and Ambesit *kebels*) of Ethiopia. Production data were collected using semi-structured questionnaires from 30 garlic producing households where the whole value chain of garlic production system were recorded. Results showed that the agronomic and cultural practices employed by farmers contributed to the low productivity of garlic. Major constraints of garlic production include lack of suitable irrigated land, lack of quality planting material, shortage of irrigation water, fertilizers and pesticides, lack of money for input purchase, and disease incidences (white rot). For enhancement of production and productivity of garlic, it is necessary to solve problems associated with the production of garlic through extension activities.

Key words: Bulb yield, households, garlic grower, productivity, water productivity.

INTRODUCTION

The amount of the irrigation water used and its time, and method of application is an important cultural practice which influences the yield and productivity of vegetable crops including garlic (Hanson et al., 2003). Smallholder farmers in Ethiopia use furrow irrigation to supply their crops with water without considering the developmental stages of the crops and environmental conditions

(Tilahun and Mulugeta, 2015). Such methods influence the economical use of irrigation water and thus crop water productivity.

Ethiopia has various agro-ecologies which are suitable for the production of vegetables including garlic. In Ethiopia, garlic is a fundamental flavoring component of many dishes. Furthermore, it is an important cash crop

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for smallholder farmers in Ethiopia as its unit price is much higher than most of the other vegetables produced (Emana et al., 2015). Therefore, garlic production both in quantity and in area coverage are increasing in the country. According to the Central Statistic Agency (CSA, 2000), garlic production in the year 2000 was estimated to be 52,262 tons, which was produced from 4,797 ha of land with the productivity of 10.9 t/ha. In 2013, however, the annual national garlic production reached to 222,548 t/21,258 ha of land with the productivity of 10.5 t/ha (CSA, 2013). More than 50% of the country's garlic production is produced in the western highlands of the Amhara National Regional State (ANRS) with a productivity level of about 11.13 t ha⁻¹. Approximately 10% of the garlic produced in ANRS is sourced from the Yilmana Densa district with a productivity level of about 10.5 t ha⁻¹ (CSA, 2013). This is lower than the regions as well as world average (16.9 t ha⁻¹) as indicated by Food and Agriculture Organization (FAO, 2012).

The low production and productivity of garlic in Ethiopia in general and in Amhara Region in particular are the results of various factors. Among which are inappropriate agronomic practices employed by smallholder farmers (Getachew and Asfaw, 2010), declining soil fertility (Belay, 2015), absence of proper diseases and insect pest management practices (Tesfaye and Habtu, 1986) and a lack of improved varieties (Teweldebrhan, 2009) and climate change (Mahoo et al., 2013). Therefore, the aim of the study was to assess farmer's garlic production practices and to identify its constraints so as to design intervention strategies that may contribute to the improvement of garlic production, which would improve the livelihood of small holder farmers.

MATERIALS AND METHODS

Description of the study site

The study was conducted at Yilmana Densa district of Amhara Regional State during the 2014/2015 irrigation season. The area is dominated by numerous small and medium scale irrigation schemes that are mostly used for the production of vegetables, including garlic (Gebrehiwot et al., 2015). The soil of the district is mostly nitosol with the pH ranging from 6.3 to 6.7 which is generally suitable for the production of garlic (Landon, 1991).

Sampling procedures

The farmer's garlic production practices were assessed in three major garlic producing *kebeles* of Yilmana Densa district (AdetZuria, Goshiye and Ambesit), which are selected purposively. From the lists of garlic producing households (HHs) which were obtained from *Kebele* Agriculture Offices, 10 HH heads from each *Kebele* were randomly selected. The proportion of the sample HH heads to the total garlic producing HH heads in each *kebele* was about 10%.

Irrigation water measurement and crop water productivity

In this regard, irrigation water used by selected sample smallholder

farmers for the production of garlic was measured by float method (University of California Agriculture and Natural Resources [UCANR], 2013), which was carried out on 20 m straight canal where irrigation water flowed and the mean values obtained from 10 smallholder farmers in each *kebele* were taken for analysis.

To find the velocity (m/s), water tennis ball was used and time (s) required for this tennis ball to travel the 20 m canal was measured. The measurement was replicated three times and the mean velocity was then multiplied with 0.85 (correction factor) to determine the average water velocity of the irrigation water (Harrelson et al., 1994).

To measure the water flow (m³), the width of the water surface in the canal was measured 10 times within the 20 m canal and the average width was taken for calculation. Moreover, the depth of the stream was measured at center, left, and right edges of the canal, which was repeated four times within the canal. The distance and the mean depth of the canal was taken to calculate the amount of water flowed. Finally, the amount of water flow (m³/s) was determined using Formula 1.

Total irrigation water used by the sample HHs for the production of garlic was then estimated by multiplying the time required to irrigate the land in each irrigation event, the number of irrigation events and the water flow using Formula 2.

Crop water productivity indicates the economical use of irrigation water that has been used for the production of a crop. It is the amount of crop yield (kg) which is produced by using 1 m³ of irrigation water (Geerts and Raes, 2009). To calculate the crop water productivity, the garlic yields obtained from the sample HHs were recorded and Formula 3 was used.

$$\text{Water flow (m}^3\text{/s)} = \text{water velocity (m/s)} \times \text{width (m)} \times \text{depth (m)} \quad (1)$$

$$\text{Total irrigation water (m}^3\text{)} = \text{time (s)} \times \text{water flow (m}^3\text{/s)} \times \text{number of irrigation} \quad (2)$$

$$\text{Crop water productivity (kg/m}^3\text{)} = \text{yield (kg)} / \text{total irrigation water (m}^3\text{)} \quad (3)$$

where kg = kilogram, m = meter, m³ = cubic meter, m/s = meter per second and x = multiply.

Data collection and analysis

The sample HH heads were collected using semi-structured questionnaires, key informant interviews and group discussions. Moreover, landholdings, garlic production area and experience of the HH heads and the value chain of garlic production system such as crop establishment, cultural and management practices, harvesting, and postharvest handling practices were surveyed through questionnaires. Furthermore, direct observations of garlic production fields were observed like insect pest and disease, and relevant governmental as well as non-governmental documents were reviewed (Office of Agriculture and Rural Development [OoARD], 2009) to collect relevant data.

All sets of data were subjected to SPSS version 20 computer software and descriptive statistics such as mean, standard deviation, frequency, and percentage were used to analyze the collected data.

Ethical considerations

For the purpose of the study, two development agents and two supervisors were trained for 2 days about the objectives of the study by the researcher and for ease of communication, questionnaires were translated into Amharic by experts and pre-

tested prior to actual data collection by undertaken interviews of similar setting with the trained data collectors. As a result of this pre-test interviewed time and some of questions were adjust and restructured. Interviewers proceed from house to house. They introduced themselves and explain the purpose of the study used specific statements in a standard procedure. Consent to participate was obtained from each interviewee.

RESULTS AND DISCUSSION

Garlic production practices

Landholdings, garlic production area and experience of the HH heads

The allocation of high proportion of land for garlic production in Adet Zuria *kebele* (Table 1) can be associated with various reasons such as could be availability of infrastructures like road, irrigation water and proximity to market where Adet Zuria *kebele* is equipped with such suitable infrastructures compared to other *kebeles*.

According to the survey results, most HH heads had less than five years of experience (Table 2), which differs with the garlic producing *kebeles*. Especially about 90% of the HHs in AdetZuria *kebele* and 70% of the HHs in Ambesit *kebele* had less than five years of experience in garlic production. These results are generally in agreement with the results presented earlier where most of the HH heads in AdetZuria *kebele* were young and thus will not have much experience in garlic production.

Garlic farm establishment in the study area

Garlic is generally produced during the main rainy season and off season using irrigation. However 93.3% of the sample HH heads produced garlic once during off season using irrigation water where garlic was mostly planted in November and harvested in March and April. Only 6.7% of the sample farmers produced garlic twice a year during main cropping, and off seasons.

Although irrigated farming requires high investment, farmers prefer to produce garlic during off season using irrigation water. According to the key informant, the incidences of white rot and garlic rust, serious diseases of garlic in the study area, are very low during irrigation season compared to rainy season. The results are in agreement with the findings of EIAR (2007) and Zeray and Mohammed (2012) which recommended the production of garlic and similar vegetables in tropical areas using irrigation water than during main rainy season because of high incidence of destructive diseases.

The use of improved varieties is a very important input to produce high quantity and quality of crop yield including garlic. Although different improved garlic varieties such as Qoricho, BishoftuNetch and Tseday 92

were released from different research institutes in Ethiopia (EIAR, 2007); farmers used only local garlic varieties sourced from their own savings and/or from local market. Planting materials sourced from such informal seed system have limitations in terms of quality as the interviewed farmers mentioned which is in agreement with the observations of Emanu et al. (2014). According to the key informants, unavailability of planting materials of improved garlic variety is a very limiting factor for the development of garlic production in the study area.

Use of appropriate planting method is important in vegetable production since it affects plant population, the growth and development of plants and thus crop yields. Hence, both over and less population of plants in a given plot of land have negative effect on crop yields including garlic.

According to the survey results, sample farmers planted garlic cloves in double row planting arrangement of 34.8 cm between double rows, 26.8 cm between rows and 11.8 cm between plants in the row which is not in line with research recommendation. According to EIAR (2007), the recommended plant spacing of improved garlic varieties is 30 cm between double rows, 15 cm between rows and 10 cm between plants in the row. Wider spacing employed by the farmers results in low density of garlic plants that in turn results in low bulb (Yemane et al., 2013). Keeping optimum garlic plant density is therefore important to improve the production and productivity of garlic.

Garlic management practices employed by the farmers in the study area

One of the features of vegetable crops including garlic is that they contain more water than other field crops like cereals. Thus, they require continuous supply of water to sustain production and productivity. According to the respondents, the majority of the farmers (93%) irrigated their garlic field using furrow irrigation method where the water is sourced from diverted rivers which is in agreement with the findings of Tilahun et al. (2010). Furrow irrigation is mostly implemented by farmers to supply water to irrigated crops including vegetables (Tlahun and Mulugeta, 2015).

Irrigation frequency depends on the prevailing climatic conditions, growth stages of crops and soil types. About 70% of the interviewed farmers irrigated their farms every week while 30% of them supplied their garlic every five days interval without considering the developmental stages of plants and the prevailing environmental conditions in the area. These results are not in agreement with the recommendations made by EIAR (2007). According to the recommendation, garlic should be irrigated two times per week at early developmental stages of plants (emergence and germination stages) and then every five to ten days interval depending on the type of soils and environmental conditions of the areas.

Table 1. Average land holdings and garlic production area.

<i>Kebele</i>	Average crop land holdings (ha)	Garlic production area (ha)	%age of garlic production area
AdetZuria (n =10)	0.75	0.24	32.0
Goshaye (n =10)	1.0	0.23	23.0
Ambesit (n =10)	0.9	0.07	7.8
Total average (n =30)	0.883	0.181	20.5

N = Number of sample HH heads.

Table 2. Experience of farmer's garlic production in study *kebeles*.

Experiences (year)	<i>AdetZuria kebele</i>		<i>Goshaye kebele</i>		<i>Ambesit kebele</i>		Total	
	Frequency (n = 10)	%	Frequency (n = 10)	%	Frequency (n = 10)	%	Frequency (n = 30)	%
≤5	9	90	4	40	7	70	20	66.7
5-10	1	10	2	20	1	10	4	13.3
10-15	0	0	2	20	0	0	2	6.7
≥15	0	0	2	20	2	20	4	13.3

N = Number of sample HH heads.

Application of fertilizers is an important cultural practice in vegetable production as it helps to satisfy the nutrient needs of crops required for the production of high yield. About 83 and 97% of the interviewed sample farmers used DAP and ureafertilizers, respectively, to produce garlic in the study area. However, only 6.6% of them used organic fertilizer which may have a negative effect on the yield of garlic. Among the *kebeles*, all the interviewed farmers in AdetZuria used DAP and urea fertilizers for the production of garlic whereas 90 and 100% of them in Goshaye used DAP and urea fertilizers, respectively (Table 3). Generally, farmers in Ambesit were less users of DAP, and urea fertilizers with the mean values of 60 and 90%, respectively, which may have negative impact on the productivity of garlic in the *kebele*.

The average DAP and urea fertilizers rates applied by interviewed HHs were about 125 and 155 kg ha^{-1} which is low compared to the recommendation made by EIAR (2007). Accordingly, the blanket recommendations of DAP and urea fertilizers for the production of garlic are 200 and 150 kg ha^{-1} , respectively. HHs in the study area perceived that their soil is fertile enough for the production of garlic so that it is not necessary to supply the recommended fertilizer rates.

Time of fertilizer application should coincide with the developmental stages and thus the need of the crop plants including garlic. Most of the interviewed farmers (72%) applied half of the quantity of DAP one month, and the remaining quantity two months after planting of garlic. On the other hand, about 75.9% of the interviewed farmers applied half of the quantity of urea one month,

and the remaining quantity two month after planting of garlic.

The time of fertilizer application employed by the sample HHs is not in agreement with the recommendation made by Sendek (2012) which may contribute to the low level of garlic yield in the study area. According to him DAP should be broadcasted some times before garlic planting followed by shallow incorporation into the soil, while urea should be applied by two split applications. Accordingly, one half of urea should be applied four weeks after planting and the remaining one half eight weeks after planting.

Diseases and insect pests are serious concern in the production of garlic in Ethiopia including the study area. Among others white rot (*Sclerotium cepivorum*) and garlic rust (*Puccini aallii*) were the serious diseases observed in the study area where their occurrence differ with the sample *kebeles*. While 80% of the garlic farms in Goshaye were infected with white rot only 10% of the garlic farms in AdetZuria and Ambesit were infected by the disease. The incidence of garlic rust in the study area was 40, 20 and 10% in AdetZuria, Goshaye and Ambesit *kebeles*, respectively. The results are generally in agreement with the findings of various researchers who found that white rot and rust are the common diseases of garlic in Ethiopia (Wale and Mengistu, 2009; Agegnehu et al., 2013; Shibr, 2013). Among the insect pests, thrips (*Thrip stabaci* L.) was the most common insect found in all garlic farms of the sample HHs which was inline with the observations of Wale and Mengistu (2009) and Agegnehu et al. (2013). Generally, the authors recommended appropriate cultural and management

Table 3. DAP and urea application time.

Description	AdetZuria (n=10)		Goshaye (n=10)		Ambesit (n=9)		Total (n= 29)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
DAP application time								
At planting	0	0	1	11.1	1	16.7	2	8
One months after planting	1	10	0	0	4	66.7	5	20
Half one month, and the remaining half two months after planting	9	90	8	88.9	1	16.7	18	72
Urea application time								
One month after planting	0	0	0	0	7	77.8	7	24.1
Half one month, and the remaining half two months after planting	10	100	10	100	2	22.2	22	75.9

N = Number of sample HH heads.

practices such as proper irrigation intervals, crop rotation, weed control and use of pesticides to manage garlic pests in Ethiopia including in the study area.

Harvesting and postharvest handling and crop-water productivity

Knowing maturity indexes is an important prerequisite to decide the time of harvesting and thus to reduce postharvest losses of crops including garlic. Garlic is ready to be harvested when the main stem above the bulb soften, 75% of the leaves become yellow and the tops begin to dry out naturally and collapse (Libner, 1989; Bachmann and Earles, 2000) which was well known by the respondent HH heads.

After digging and uprooting, 76.7% of the respondent HH heads practiced curing/drying by spreading the garlic bulbs in shady places to reduce postharvest quality deterioration which is in agreement with the recommendations of Tindal (1983), Libner (1989) and Bachmann and Earles (2000). In contrast, 60% of the sample HH heads in AdetZuria *kebele* did not dry their garlic after

harvesting, as they will sell their produces immediately after harvesting. Such practices reduce the storability of garlic and increase postharvest loss as indicated by Tindal (1983).

After curing garlic bulbs should be stored in clean and well ventilated storage either in container or spread in floor or any other structure. Farmers in the study area store their garlic in polyethlynebags or spread loose on above ground structure (*kot*) and or groundfloor. While polyethylene bags were used to store garlic for short period of time, spreading of garlic on above ground structure or ground floor helped them to store garlic for relatively long period of time (up to two months).

If properly cured and stored in well ventilated and cold storage, garlic can be stored for a long period of time without quality deterioration (Tindal, 1983). However, garlic storage practices in the study area is not as such suitable for long term storage, since it lacks proper curing process and appropriate storage structures like cold storage. Moreover, farmers produce garlic for immediate sale to improve their income.

The average garlic productivity which was obtained from the farms of the sample HH heads

and crop-water productivity of each *kebele* are presented in Table 4.

Accordingly, the productivity of garlic in AdetZuria *kebele* (10.73 t ha^{-1}) was relatively higher than the other two *kebeles* where the average garlic productivity of the study area was about 8.39 t ha^{-1} . Generally, the productivity of garlic in the study area is lower than that of the West Gojjam Zone (10.5 t ha^{-1}) and the Amhara Region as a whole (11.13 t ha^{-1}) as indicated by CSA (2013). This low productivity of garlic may be attributed with inappropriate agronomy practice, absence of proper disease and insect pest management practices, absence of improved variety, and other which is in conformity with results of Tesfaye and Habtu (1986), Teweldebrhan (2009) and Worku and Dejene (2012).

Regarding to crop-water productivity, there are differences among the study *kebeles*. Garlic producing HHs from AdetZuria *kebele* scored relatively higher crop-water productivity with the value of 0.744 kg ha^{-1} followed by those from Goshaye (0.613 kg ha^{-1}) and Ambesit *kebeles* (0.483 kg ha^{-1}). The average garlic water productivity of the study area was generally very

Table 4. Garlic and crop water productivity.

Description	AdetZuria (n=10)	Goshaye (n=10)	Ambesit (n=10)	Total (n= 30)
	Mean	Mean	Mean	Mean
Garlic production area (ha)	0.24	0.23	0.074	0.181
Garlic productivity (t ha ⁻¹)	10.73	7.83	6.62	8.393
Total water used (m ³)	3,459.4	2,935.8	1,014.8	2,470
Total water used (m ³ ha ⁻¹)	14,414.17	12,764.35	13,713.51	13,630.68
Crop water productivity(kg/ m ³)	0.744	0.613	0.483	0.613

N= Number of sample HH heads.

low (0.613 kg ha⁻¹). According to the findings of Haileslassie et al. (2009), the garlic water productivity in Gumara watershed (Blue Nile Basin) is about 0.9 kg ha⁻¹. The low garlic water productivity may be attributed by the general low productivity of garlic in the study area (8.393 t ha⁻¹) and probably over irrigation. According to MoANRS (2011), the recommended irrigation water required for one season garlic production is estimated to be between 9,000 and 14,000 m³ha⁻¹.

Major constraints and opportunities of garlic production in the study area

According to the survey results, key informant interviews and group discussions, the major constraints of garlic production in the study *kebeles* were limitation of irrigable land, unavailability of improved and high yielder varieties, shortage of finance for input purchase, disease and insect pests, shortage of irrigation water and chemicals (fertilizers, pesticides). However, their degree of importance differs with sample *kebeles*. Limitation of irrigable land shortage of finance for input purchase were the biggest problems of the sample research group in AdetZuria *kebele*, while in Goshaye the prevalence of white rot disease and unavailability of improved garlic varieties were the major constraints of garlic production. In Ambesit *kebele* shortage of irrigation water, limitation of irrigable land, shortage of finance and chemicals were the major constraints of garlic production.

Although various constraints, according to the respondents, there are also opportunities that help to improve the production and productivity of garlic in the study area. These are summarized as follow:

- (1) The expansion of small- and medium irrigation infrastructures by the federal as well as regional governments;
- (2) The increased awareness of the farmers towards the production of cash crops that contribute to the improvement of farmer's livelihood;
- (3) The increasing demand of Ethiopian vegetables in the regional markets like Djibouti, Somalia, South Sudan and Sudan and the increase of the market prices of

vegetables;

- (4) Due attention of the agricultural research institutes towards vegetable research and release of some improved varieties of vegetable crops including garlic; and
- (5) The ever increasing extension services of the governmental agricultural offices towards production, management, and postharvest handling practices of cash crops like vegetables.

Conclusion

Garlic is an important cash crop for smallholder farmers in Ethiopia including for those in Amhara Region. The production and productivity of garlic in Ethiopia is by far lower compared to other countries which requires research and extension services. To this end however, information about the current garlic production practices are paramount important to design intervention strategies.

The assessment of the present study revealed that garlic in the study area was mostly produced by smallholder farmers in the study area allocated about 7.8 to 32% of their crop land for the production of garlic where the farmers in AdetZuria *kebele* allocated relatively high proportion of their crop land for garlic production.

Productivity and irrigation water productivity of garlic in the study area is relatively low with the values of 8.39 t ha⁻¹ and 0.613 kg/m³, respectively. The low productivity of garlic may probably associated with improper agronomic and management practices employed by the smallholder farmers in the study area which includes improper spacing, lack of improved and high yielder varieties, low level of fertilizer use, high incidence of diseases and insect pests and unavailability of pesticides. Moreover, the production of garlic in the study area was constrained with limitation of irrigable land and shortage irrigation water and lack of finance for input purchase which contributes to the low yield of garlic in the study area.

Nevertheless, the study area has also huge opportunities for the improvement of garlic production which include due attention of the government for vegetable production, the increase of demand and

market price of vegetable crops and awareness of the farmers towards the economic and nutritional values of vegetable crops.

Recommendations

The findings indicated that YilmanaDensa district has a huge potential in the production of garlic production. However, its production is facing a lot of constraints which require various intervention strategies which include among others:

- (1) Upgrading the skills, knowledge and attitudes of the smallholder farmers in the agronomic, management, and postharvest handling practices of garlic;
- (2) Improving the availability of inputs such as improved garlic varieties, fertilizers, pesticides, and irrigation equipments
- (3) Developing the availability of water bodies through intensive soil and water conservation activities, rain water harvesting technologies and spring water development measures.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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