VOL. 12, NO. 8, AUGUST 2017 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

POTENTIALS AND CONSTRAINTS OF GARLIC PRODUCTION IN SOUTHERN REGION, ERITREA

Daniel Zeru Zelelew[1], Tesfai Tsegai Kidane[2], S. Danish Y. Naqvi[3] and Ananta Suryanarayana K.[2]
[1]Department of Horticulture, Hamelmalo Agricultural College, Eritrea
[2]Department of Agricultural Economics, Hamelmalo Agricultural College, Eritrea
[3]Department of Plant Protections, Hamelmalo Agricultural College, Eritrea
E-Mail: danizeru43@gmail.com

ABSTRACT

Garlic is the second most important bulbous vegetable crop used as spice, condiment and has medicinal value. In Eritrea it is a commercial vegetable crop growing in the midland and central highlands by small scale farmers. Despite its importance and significant potential to boost production; its production, productivity and thus supply of the crop in the market are very limited and remain seasonal. The current study is therefore designed to investigate the trend, potentials and constraints of garlic production. The survey was conducted in the main garlic producing areas of the Southern region. Data was collected using structured questionnaire and group discussions through participatory rural appraisal method with garlic growers and interviews with staff members of the Ministry of Agriculture. The result indicated that garlic is produced with low input and low output practices. Farmers have indigenous knowledge of garlic production developed through experience. Farmers prefer to grow the crop because of easiness to grow, long time storability, high selling price and market demand. Most common insect pest and diseases are reported viz. thrips, rust and purple blotch, may responsible for 25 up to 100 percent yield loss in favourable environmental conditions. The result also showed that lack of high yielding certified seed, lack of fertilizers both in kind and quantity, lack of plant protection facilities, land insecurity, lack of fuel and poor extension services are among the main bottleneck of garlic production. It is therefore recommended that to improve the production and productivity of garlic, standard national and regional seed supply system and storage facilities has to be established; availability of main farm inputs have to be secured and regular extension services should be provided.

Keywords: garlic, constraint, Eritrea, production, potential, southern region.

INTRODUCTION

Garlic (*Allium sativum*) is the second most important commonly used and cultivated bulbous crop after onion worldwide (Shinde *et al*., 2003). Garlic is produced for fresh market, dehydrated as ingredient for food processing, and food supplement output like dehydrated powder, essential oil, oil macerate, powder, and aged garlic extract (Wiczkowski, 2011). It is also a fundamental component in many dishes of various cultures (Kero, 2010) and has medicinal values (Tsai *et al*., 2012 and Nagy *et al*., 2015). Garlic; due to presence of diallyl sulfide and triallyl sulfide shows fungicidal property against seed borne fungus. Garlic extract spray has a broad spectrum effect (Olkowski *et al.,* 1995). Garlic contains nearly three times as much sulfur-containing compound as onions (11–35 mg/100 g fresh weight) (Lawson, 1996). Because of its multifunctional properties, area under cultivation worldwide increased from 846,300 hectares in 2007 to 1, 199,929 hectares in 2010 with a total production from 65,000 to 17,674,893 tonnes (FAO, 2012). China being the leading garlic producer is contributing around 20 million tonnes annually, accounting over 81% of world total production with the productivity of 23.53 t/ha. African countries like Egypt produced 309,155 tonnes with productivity of 24.34 t/ha which makes it top African producer and Ethiopia produces 224,548 tonnes with productivity of 10.47 t/ha (FAO, 2015).

In Eritrea garlic is an important highly priced cash crop grown by small-scale farmers having significant role in their livelihood. Its production is concentrated in the midland and highlands particularly in southern and central region of the country. Garlic is placed as the second most important irrigated (furrow or basin) bulbous crop after onion. In the recent years, area under cultivation and production of garlic in Eritrea in general, southern region in particular, has shown continuous increment with an average productivity being 6 t/ha (MOA, 2015). Garlic plays a magnificent importance as spice, condiment, medical plant as well as cash crop. It is highly used by all cultures of Eritrean society for the preparation of various dishes as to add taste and make the food more palatable and digestible. It is the main component of most favourite Eritrean traditional dish *shiro* which needs quality and high amount of dehydrated garlic bulbs. The pleasant aroma and unique taste of garlic (Goldy, 2000 and Nagy *et al*., 2015) is also one of the major factors that make *shiro* popular and favourite Eritrean dish. Farmers prefer to grow the crop because of its high selling price and demand in the market, easiness to grow and long time storability. Besides the amount of seeds required to cover one hectare is less as compared with other vegetables like potato

Despite its importance, great potential for production and high market demand, the present garlic production and productivity in Eritrea is very limited and remain to be seasonal. This leads the country to import large quantity of garlic bulbs using hard currency as to fulfil the market demand. During the year 2005 about 27.7 tonnes of garlic bulbs costing 149,139 USD were imported from other countries (MoF, 2007). The major garlic

production constraints in Eritrea are believed to be poor crop management practices (MoA, 2005), lack of high yielding certified seed varieties, non availability of appropriate plant protection chemicals and absence of region wise standardize packages of practices (Gemie, 2007). In 1980 it was estimated that the annual production loss due to plant diseases in United State of America was about four billion dollars (Steferud, 2010). While in Eritrea overall loss caused by the diseases has not been estimated yet that could be probably more than in USA, considering that the quantum of preventive measures taken to prevent the crops from the insect pest and diseases is far below that of USA. Thrips, purple blotch and rust are widespread and often quite serious in all regions wherever there is garlic cultivation. Reports of the Ministry of Agriculture, the State of Eritrea (2011) also indicated that the high cost of inputs especially seeds; fungicides and fertilizers, and shortage of fertilizers both in quantity and type resulted in no application at all or were applied below the recommended rate. However, this needs to be explicated through a survey at ground level. More detailed crop specific survey helps to respond into the multiple and complex limitations affecting the production system and more effective targeting of research and development efforts on the crop (Asgedom *et al*., 2011 and Biniam *et al*., 2014). It is in the view of this background that the current study was designed to investigate the trend, constraints and potentials of garlic production in Southern region, Eritrea. Special attention was given to the varieties used, seed source, land preparation, planting season, fertilizer application, fertilizer sources, irrigation, control of pests and diseases, yield, storage, produce transportation and marketing systems. These findings can be used as a benchmark for further investigation and prioritization of research areas for the improvement of garlic productivity in the area.

MATERIALS AND METHODS

Site description

The study was conducted in southern region of Eritrea, in sub-regions of Dubarwa and Emnihaili during the year 2016. These areas were selected purposely because they are the major garlic growing areas in the region. Southern Region is located along a portion of the national border with Ethiopia 14º25'-15º10' N latitude and 38º15'-39º-45' E longitude. It is the largest region in the country by population. The soil type of this region is dominated by *Cambisol*, *Lithosol-Cambosol* and *Vertic-cambisol* (FAO, 1988). In southern region, agriculture is an important economic activity where for the majority of the population it remained to be a source of livelihood, employment and food security (Biniam *et al.,* 2014).

Data collection and analysis

Data was collected from 50 farm households selected through deliberate and stratified random sampling from the two sub-regions of the southern region, Eritrea. The number of respondents from each sub-region was determined by proportionate sampling. Data was collected using structured questionnaire and group discussions through participatory rural appraisal method with garlic growers. Both quantitative and qualitative data about the farm households' socioeconomic characteristics, the varieties used, seed source, land preparation, planting season, fertilizer application, fertilizer sources, irrigation, control of pests and diseases, yield, storage and marketing functions were collected. A check list of topics was prepared to guide the group discussion. The participant of the group discussion included farmers of different age, capital, educational background and experiences. On top of this, secondary data about the yield history and general production constraints and potentials was collected from the head quarter of MoA and Southern region branch. The quantitative data of the primary information was subjected to a statistical analysis using IBM SPSS statistical package version 20 for computational analysis after which results were expressed in the form of averages, and percentages. Moreover logical analysis was used to identify the potentials and constraints of garlic production raised by staff of MoA and farmers during group discussion.

RESULTS AND DISCUSSIONS

Socio economic characteristics of households

The results showed that 94.9% of the households were headed by male while the remaining 5.1 % were female headed. This indicates that majority of the garlic growers in the surveyed area are male headed households. Similar results were reported by (Saleh *et al*., 2013) for pepper producers in Eritrea. Age of the respondent ranged from 29 to 80 years with an average being 52 years. The results also revealed that 61.5% of the respondents were in the age range of 40-60 years; 25.6% are elders greater than 60 years old and only 12.86 % are 25-40 years. This shows that cultivation of garlic is relatively common among the older farmers. This could be due to the fact that young people are engaged in national and community services or they tend to work in urban areas other than agricultural sector. The result further showed that about 61.5% of the growers had either junior or high school, 33.35% are either illiterate or had elementary school and only 5.5% had post-secondary education level. Family size of households ranged from 3 to 10 years with an average being 6 persons. With regard to farmers' experience 71.8% of the respondents had less than 10 years, 23.1% had 10-20 years and only 5.1% had greater than 20 years of experiences. This indicates that most of the farmers are new to garlic production and garlic cultivation is being introduced in recent years.

Farm land and soil fertility

The land tenure system of all the surveyed areas is *dessa* and land share between the owner and farmer. *Dessa* is the main land tenure system used in most part of the highlands of the country where land use rights rest with the village (Negassi, *et al*., 2002). The land is classified as fertile, semi-fertile and poor, and each member of the village is entitled to plot in each category where, it is redistributed every 5 to 7 years (Stillhardt *et*

al., 2003). Almost all the respondent mentioned that the system discouraged them from long-term land use planning and management leading to over cultivation. In line with the current findings Negassi, *et al*., (2002) concluded that *dessa* does not encourage growers to put long-term investment in improving the land; knowing that it will be redistributed to others after certain interval thus, resulted poor soil fertility. Bein *et al*., (1996) also reported that long history of cultivation, and grazing without recycling of nutrients or management of organic matter in this region, resulted in poor soil fertility and depleted vegetation. Therefore, low soil fertility was found to be the tribulation of garlic production in the surveyed area. Similarly Muriithi and Irungu, (2004) reported that low soil fertility is one of the most important constraints limiting vegetable production in Eastern Africa and hence accelerated and sustainable agricultural intensification is required for suitable production.

Figure-1 showed that the overall area under garlic cultivation in southern region has increased by about 828% from the year 2005 to 2015 (MoA, 2016). This Indicate that garlic is becoming preferable vegetable crop in the region which could be due to the high demand and market price of the crop. However between the years 2008-2009 there was a decrease which could be attributed to the severe drought that caused acute shortage of water for irrigation activities. The result also showed that cultivable land of the surveyed area varies from farmer to farmer. An average land size was 3.39 ha with minimum and maximum of 1 ha and 14 ha respectively. Furthermore it was found that land allocated for garlic production ranges from 0.25 to 2 ha with an average of 0.72 ha among the individual farmer (Table-1). This implies that garlic is cultivated by small scale subsistent farmers. The same farming pattern was reported in Ethiopia (Adem and Tadesse, 2014). Moreover, durging the group discussion it was noted that farmers with larger cultivable land and higher capital tend to allocate greater land for garlic production than those with smaller land. Comparing between the two sub-regions, Dubarwa has largest area under garlic cultivation than Emnihaili. Almost all of the farmers (97.45%) responded that garlic cultivation is done in flat areas out of which 78.9% is silt clay, 15.4% sandy loam, 5.1% sand and 2.6% is loam. It is practically observed that the cultivated area of the two sub regions is dominated with flat and some gentle slope. The topographic nature of southern region is characterized by more plateaus and flat area ideal for large scale commercial farming (Biniam *et al*., 2014). This could be the main reason why area under garlic cultivation and production is more in Southern region than any other regions in the country.

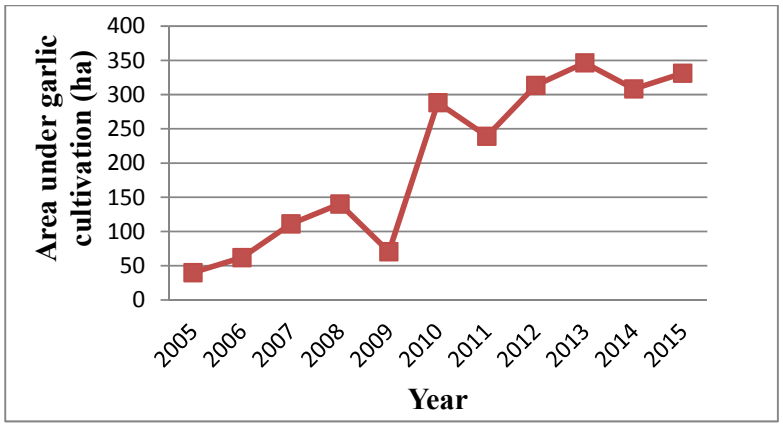

Figure-1. Trend in total area under garlic cultivation (ha) (MoA, 2016).

Table-1. Land (ha) allocated for garlic production by an individual farmer.

Sub-region	Minimum	Maximum	Average
Dubarwa	0.25	2	0.97
Emnihaili	0.25	1	0.39
Average	0.25	2	0.72

Methods to maintain and improve soil fertility

For highest yield and better quality of bulbs, garlic requires higher fertilizers application with a balanced nutrient management. The result of this study indicates that farmers are conscious about the importance of both organic and mineral fertilizers for improving yield and quality of their crops. During the group discussion it was noticed that the farmers are unable to estimate the average amount of fertilizer applied to the crop. Moreover, the amount of fertilizers applied varies with time, farmers' wealth and soil type but it is far below the recommended rate. The main reason for this lower application is that farmers are not able to afford the high cost of fertilizers and are scanty in the market. In close agreement to the

current study Negassi, *et al*., (2002) reported that most farmers in Eritrea apply inorganic and some organic fertilizers to boost the yield of commercial crops, the amount and kind they apply depends on financial resources, cost, availability, soil fertility and crop type. The most common and frequently used once are DAP, Urea and FYM. Ministry of Agriculture, the State of Eritrea (2011) also stated that the high cost of inputs especially fertilizers, and shortage of fertilizers both in quantity and type resulted in no application at all or are applied below the recommended rate. Moreover, about 43% of the respondents reported that they use only Urea, 13 % FYM, 28% both Urea and DAP, 3% Urea and FYM and 13 % combination of Urea, DAP and FYM (Figure-2). The farmers stressed that FYM and DAP are applied during land preparation while urea is applied after crop establishment during cultivation. It was also noted that the farmers are unable to see the immediate effect of DAP which is the main reason for no application of it separately. Farmers of the surveyed area have expressed their concern that there is acute shortage of inorganic fertilizers and are too costly to be used by the majority of farmers. Most of the respondent (76.9%) reported that there are very limited amount of fertilizers available in the market from informal source. Few (5.1%) get fertilizers from farmers' cooperative associations and only 2.6 % are getting from MoA. While organic fertilizer (FYM) was obtained from own sources or local cattle producers. In Eritrea there is no frequent and regular supply of mineral fertilizers for the farmers either by Ministry of agriculture or local market.

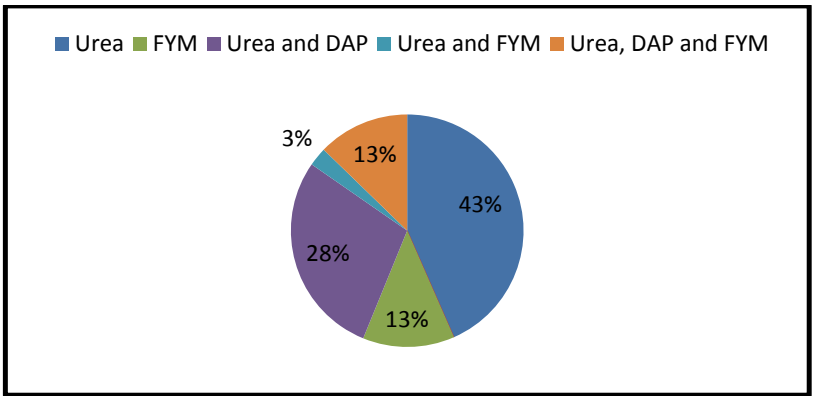

Figure-2. Organic and inorganic fertilizers used by garlic growers.

Planting season and seed source

Garlic is cool season frost resistant crop which needs moist period during growth and relatively dry during maturity. Farmers of southern region plant garlic in two different seasons. The main planting period is during autumn starting from mid September to late October which is the most suitable because of the cold weather and the second option is spring (March-June). Garlic planted in the former period gives higher mean yield and better quality as compared with the later. Similar results were reported by (Rana, 2008) for Northern part of India. However, more leaf rust was prevalent with those planted on autumn. The weather in the autumn season especially between December and end of January is characterized by cold and wet weather condition which could be conducive for the growth and development of leaf rust. The main reason for farmers to grow garlic during the off-season (spring) is to make use of the higher price resulted because of limited market supply in that period. Garlic planted at this period will be prone to purple blotch, lesser yield but are sold twice or thrice of the value of the on-season product.

Availability of high yielding certified seed varieties is the base for improvement in the productivity and quality of any crop and it was found to be one of the main limiting factors of garlic production in the surveyed area. Stored seeds are not treated from any pesticides to make them safe from different pests. Seed treatment is an old age practice for plant protection. It has enormous benefits in comparison with traditional crop protection methods. It not only to improve the seed quality and manage the seed borne pathogens and insects, but also improves stand quality, protect seed from seed and soil borne pests, improved seed shapes for transplanting, increase yields, increase return or investment, improve seed storability. Seed treatment with systemic pesticides also reducing active ingredient loading in the environments and decrease the effect on non target organisms and environmental safety. The most commonly cultivated varieties are *four months early, six months late* and there are also some varieties with no name imported from Ethiopia and Yemen. Farmers choose the varieties of garlic depending on various characteristics like marketability, yield, earliness and resistance to diseases. The study revealed that 53.9% of the respondent chooses the varieties based on marketability, 41.1% on yield, 30% earliness and 10.3% on diseases resistance. During the group discussion formers noted that *early four month* is most preferred because of earliness, diseases resistance and higher marketability. The cultivar imported from Ethiopia producing bulb with purple stripe cover is preferred because of higher market demand and diseases (rust fungi) resistance. Garlic bulbs with beautiful purple lines and stripes are very attractive and are getting higher

market demand. There is no reliable resource to get the pure and healthy seed in whole country. The most important seed sources include own-saving from previously harvested, unknown market, and other farmers. Majority of the farmers prefer to use own saved and recycle the planting material year after year which is commonly practiced by most traditional farming systems. Farmers consistently preserve own seed as to have a back-up in case of crop failures and unavailability of seeds in the market. Garlic seeds lose their viability within one year due to infestation with different storage pests. Especially seed borne pest not only be damages single seed but can also serve as infection foci for secondary infection. Thus, resulted some limitations in terms of quality of planting materials, infection with diseases consequently low yield and quality products (Ayana *et al*., 2014). The study further investigated the seeding rate of garlic followed by the farmers. The seeding rate ranges between 80 to 200 kg/ha of garlic bulbs. The average seeding rate in the two sub-regions was almost similar being 139 kg/ha and 142 kg/ha for Dubarwa and Emnihaili respectively which is much lower as compared to 500-600 kg/ha (Rana, 2008). The low seeding rate could be attributed to varieties used with more number of cloves, smaller clove size, wider planting density and seed shortage to the farmers.

Land preparation and irrigation

Land preparation is a very important practice that involves ploughings to pulverize the soil before making the ridges or basing for planting the cloves. Almost all the farmers in the surveyed area agreed that land for garlic production should be a land, which was previously cultivated with potato or legume crops like beans otherwise fallow and should be ploughed two to three times at least a month before planting. Farmers believe that, this method helps to maintain soil fertility, benefit from the fertilizers applied for potato production, in reach the soil with more nitrogen fixed by the legume crop and freed their crop from insect pest and diseases thereby boost garlic productivity. Farmers used different methods to prepare their land such as manual labour and animal driven equipment (64.1%), a combination of manual labour, animal driven equipment and tractor (30.8%) and only manual labour (5.1%). Manual labour land preparation was practiced only in sub-region Emnihail (Table 2). The main reason for dependency on manual labour and animal driven equipment for land preparation in this region is because of smaller acreage of land owned by the farmers which is unsuitable for tractor operations (Saleh *et al*., 2013).

Garlic production in the surveyed area is done fully under irrigation. Most of garlic producing farmers use basin (61.5%) or furrow (33.9%) while only very few (2.6%) use drip irrigation. Similar results were reported by Stillhardt *et al*., (2003) who noted that most small-scale irrigation farmers of Eritrea use furrow and basin irrigation systems for crops such as onion, tomato, pepper, potato and leafy vegetables. Farmers prefer to irrigate their crop in the morning, thus allowing sufficient time for the plant foliage to dry before nightfall (Allen, 2009) and reduce the incidence of fungal diseases. Almost all growers (97.4) also mentioned that the main water source for irrigation is well and very few (2.6%) depends both on well and dam. During the group discussion it was noted the water content of the wells is highly rainfall dependent. During poor rainy season the farmers tend to reduce their cultivable land due to reduced water tables. Moreover the farmers agreed that water shortage during poor rainy season and some period of the year (April - June) becomes the main constraint of production. All farms use water-pump generators to collect and distribute irrigation water from wells and dam into the basin or furrow. This is in a complete conformity with the previous report by (Asgedom *et al*., 2011).

Table-2. Land preparation methods used for garlic production (%).

Sub-regions	Manual labour	Manual labour and animal driven	Manual labour, animal driven and tractor
Dubarwa	0.0	59.1	40.9
Emnihaili	11.8	70.6	17.6
Average	5.1	64.1	30.8

Disease and pest control methods

Garlic is susceptible to the same diseases and insect pest problems as onions but generally to a lesser degree. The most common insect pest and diseases found in Eritrea causing economical losses of garlic are purple blotch, rust and thrips. Thrips are a polyphagous pest on many crops, vector of virus diseases of tomato, chilli, okra and other crops and injury is also favourable for entry the fungal pathogens. The leaves of attacked plants are silvered and flecked. Garlic leaves are often distorted, and sometimes they die; occasionally entire crops may be destroyed (Thind and Jhooty, 1982). A wide range of insecticides are used against the thrips Malathion, phorate granules applied in soil to kill pupae. Other pests of garlic are common aphid, leaf miner, onion fly. All the respondent mentioned that leaf rust is the most serious diseases of garlic planted on the on-season (September to October) and they sometimes cause a total yield loss of the crop. The leaf rust occurs most frequently under conditions of high humidity and low rainfall (Janet and Tammy, 2008). While purple blotch is more prevalent on spring planted garlic which, could be due to the warmer and humid condition (Rana, 2008). During the group discussion farmers mentioned that there is no effective

chemical fungicide in the market for the control of leaf rust and purple blotch. 59% of the respondents depend on chemical fungicides (*Mancozeb or Zulfo)* to control these pests. While the remaining 41% depend on cultural practice like variety selection, time of planting, crop rotation, ash application and irrigating their crop during late morning hours. This is in a close agreement with (Goldy, 2000 and Rader and McGuinness, 2015) who reported that the best way to control diseases in garlic is to follow sound rotation practices, plant only clean seed stock and maintain healthy plantings through proper water and nutrient management. The purple blotch, apart from being seed borne in nature, is known to overwinter from one season to the next as mycelium and spores in leaves and seed stalk left as debris in the field after harvest. The secondary infection is caused by airborne inoculums. Role of thrips injuries in predisposing garlic plants to purple blotch infection has been established and control of thrips by Malathion (0.2%) significantly reduced the severity of the disease (Hell and Waller, 1994). For the control of insect pests formers use different types of insecticides based on their availability and cost. The most commonly used insecticides in the surveyed are *Malathion, Dursban, Tafaban, Focus* and *Roger.* It was noted that the insecticides were less effective. This could be ascribed to the low application dosage, inappropriate application of pesticides both in time and method and the chemicals might be expired. The reason for the low application dosage can be the acute shortage of pesticide availability to majority of the farmers (Biniam *et al*., 2014). Farmers get very limited amount of these chemical insecticides from MoA or farmers cooperative, and they more depends on market.

Yield and storage

Data depicted in Figure-3 indicated that the overall garlic production in southern region is increasing from 276 tonnes in 2005 into 1988 tonnes in 2015 (MoA, 2016). This result can be ascribed to the sharp increase in the number of garlic producers and area under garlic cultivation in that region (Figure-1). The increased investment in garlic could be due to the economic incentive created by higher market price of garlic as compared to other vegetable crops. The study further investigated the yield of garlic in the study areas ranges from 1.6 t/ha up to 10 t/ha and an average been 4.4 t/ha. There was also a yield variation between the two sub-regions. Maximum yield in Sub-region Dubarwa was 7 t/ha while it was 10 t/ha in sub-region Emnihaili. This yield variation might be attributed to the variation in climatic and soil conditions, varieties used and farming practices followed by the farmers. Majority of the respondent also mentioned that the yield obtained from the crop planted in autumn season is higher than those planted on spring. This could be due to the cold weather which is suitable for mother bulb to split into cloves (Bachmann, 2001) and more availability of water for irrigation.

Garlic has good storage properties and endurance during transport, and as a result they are traded more widely in comparison to other vegetables (Wiczkowski, 2011). Result of the survey revealed that most (84.6%) of the farmers replied that they do not have storage facilities for their produce and they immediately took them to the market. While the remaining (15.4%) responded that harvested bulbs are stored in an ordinary storage. In the group discussion it was further noted that garlic bulbs for storage are cure in shaded area for more than a week and braided in to bundles. The bundles are then stored by hanging them in a wood sticks or roof of traditional houses which is not commercially feasible (Rana, 2008). However, it is worth mentioning that farmers are able to store the bulbs for more than 8-10 weeks that helps them to get a higher market price during the off-season.

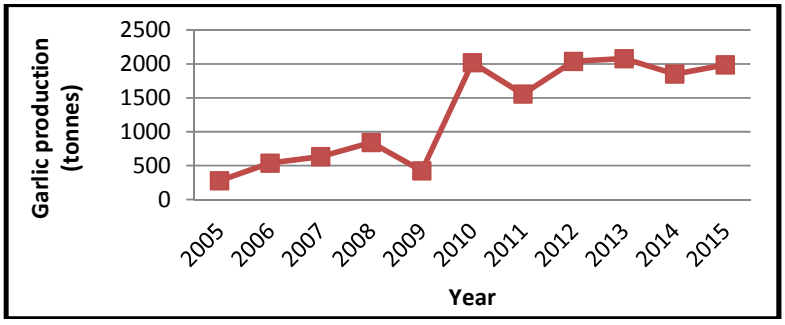

Figure-3. Garlic production (tonnes) trend in Southern region (MoA, 2016).

Marketing function

Garlic is highly demanded and priced vegetable grown as a cash crop in Eritrea. As a spice it constitutes relatively small portion of household's expenditure. This makes the demand of garlic relatively inelastic to price changes. Its price varies from 50 ERN/Kg in the production season (August-October) up to 270 ERN/Kg in the off season (January-March). Almost half (51.3%) the farmers sell their produce directly to wholesalers, 5.1% to retailers and 43.6% to both wholesalers and retailers. Framers with stores (15.4%) were able to get better prices of their produce even though some of the price gain is offset by the reduction in the marketable weight of garlic. Moreover, those farmers who are able to market their

produce directly to retailers and consumers on the market days of the nearby towns of Mendefera and Dubarwa were able to secure greater share of the final value of their produce. Similarly those farmers who use their own means of transport were found to reach the market early and secure better price. Furthermore, it was observed that there is a slight variation in price between the two sub-regions. In Dubarwa the minimum and maximum prices were 60 and 150 ERN/Kg respectively with an average price being 101.6 ERN/Kg. In Emnihaili the minimum price was 50 ERN/Kg and the maximum price was 270/Kg with an average price of 108 ERN/Kg. This could be attributed to the larger production area of garlic in sub-region Dubarwa that resulted higher market supply. The overall average price was found to be 104.5 ERN/Kg.

Extension services

Extension workers are the link between farmers and a research programme. For effectiveness and efficiency in agricultural production, Extension workers should be deployed at the lowest state levels closer to the farmers give advice on how to improve farming practices on food production (Roling, 1988). Village extension workers disseminate innovations from the research programme to farmers with the aim of increasing yields. At the same time, they could communicate production problems from the farmers to the research programme for solutions. The result of the current study showed that some agricultural experts (extension agents) are deployed at each and every administrative villages of sub-region Dubarwa as a pilot project. However, the services and functions given by them are below farmers' expectation. This could be due to the combined effect of low education and training level of extension agents and farmer (Saleh *et al*., 2013). Besides the extension agents are inadequate and are not well equipped in capital and transportation facilities. The extension services given in sub-region Emnihaili was found low as compared to Dubarwa. The service given to the farmer is from the office of the sub-region branch. The general or conventional extension approach (top-down approach) is practiced as a means of technology transfer from the MOA to farmers. During the group discussion it was noted that the services given is very limited and is production oriented. Moreover, the frequency of change agent and extension staff meeting is very low, utmost three times a year.

Constraints and potentials

Garlic is an important highly priced cash crop grown by small-scale farmers playing significant role in the livelihood of the subsistent farmers of the midland and highlands of Eritrea. The area under garlic cultivation and total garlic production is increasing from time to time (Figure-1 and Figure-3). However, the average yield (6 t/ha) of southern region Eritrea (MoA, 2016) is much lower than the standard and neighboring countries. The current study therefore discovered that unavailability of high yielding certified seed varieties, high cost and acute shortage of fertilizers and pesticides and prevalence of leaf rust in the on-season are the main tribulations of garlic production in the surveyed area. Besides, the land tenure system that discouraged them from long-term land use planning and management, low soil fertility, lack of fuel for their water pump, poor extension services and water shortage during off-season are also considers as limiting factors. Moreover it was noted that the availability of favourable climatic conditions, high selling price and market demand, good storage properties and endurance during transport, easiness to grow, easy transportation access, low seeding rate and indigenous knowledge of farmers on garlic production are the potentials that encourage farmers to expand garlic production.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that garlic is produced by small scale farmers and land allocated by a farmer for garlic production ranges from 0.25 to 2 ha with an average of 0.72 ha. The area under garlic cultivation and total garlic production in southern region is increasing from time to time. Farmers of the surveyed area have good insight about the importance of garlic and indigenous knowledge of garlic production practices developed through long time experiences. However, they are not following the appropriate cultural practices because of many constraints. Almost all respondent mentioned that *dessa* land tenure system discouraged them from long-term land use planning and management and are over cultivating their farmland. Farmers agreed that there is acute shortage of farm inputs like high yielding certified seeds, fertilizers and plant protection chemicals thus, mainly depend in the market and remain to be main limiting factors of garlic production in southern region. The most common and frequently used fertilizers are DAP, Urea and FYM. Similar to farmers conclusion Ministry of Agriculture, the State of Eritrea (2011) also stated that the high cost of inputs especially fertilizers, and shortage of fertilizers both in quantity and type resulted in no application at all or are applied below the recommended rate. Majority of the farmers prefer to use own saved seeds and recycle the planting material year after year thus, resulted for diseases transmission and yield reduction. Furthermore it was noted that leaf rust, purple blotch and thrips are the major diseases and insect pest of garlic. Low soil fertility, lack of fuel for their water pump, poor extension services and water shortage during dry season are also considers as limiting factors. It is therefore recommended that to improve the production and productivity of garlic, standard national and regional seed supply system and storage facilities has to be established; availability of main farm inputs have to be secured and regular extension services should be provided.

ACKNOWLEDGEMENT

The authors are thankful to Hamelmalo Agricultural College for facilitating the research activities. Ministry of Agriculture head quarters office, Southern region and sub-regional branches for their unreserved support during the study period and provision of data.

REFERENCES

Adem B.E. and Tadesse S.T. 2014. Evaluating the Role of Nitrogen and Phosphorous on the Growth Performance of Garlic (*Allium sativum* L.). Asian Journal of Agricultural Research. 8(4): 211-217.

Allen J. 2009. Garlic production. Factsheet, Order No. 09-011W AGDEX 258/13. www.ontario.ca/omafra

Asgedom S., Struik P.C., Heuvelink Ep. and Araia, W. 2011. Opportunities and constraints of tomato production in Eritrea. African Journal of Agricultural Research. 6(4): 956-967.

Ayana A., Afari-Sefa V., Emana B., Dinssa F.F., Balemi T. and Temesgen M. 2014. Analysis of Vegetable Seed Systems and Implications for Vegetable Development in the Humid Tropics of Ethiopia. International Journal of Agriculture and Forestry. 4(4): 325-337.

Bachmann J. 2001. Organic Garlic Production. www.attra.ncat.org

Bein E., B. Habte A. Jaber Ann Birnie and Bo Tengnas. 1996. Useful Trees and Shrubs in Eritrea: Identification, propagation and management for agricultural and pastoral communities. Reginal Soil Consrvation Unit, Nirobi, Kenia.

Biniam M.G., Githiri S.M., Tadesse M. and Remmy W.K. 2014. Diagnostic survey on potato production practices in Eritrea. ARPN Journal of Agricultural and Biological Science. 9 (12): 444-453.

FAO 2012. Area and production of countries. Retrieved December 14, 2015. www.faostat.fao.org.

FAO 2015. Major Food and Agricultural Commodities and Producers Countries by Commodity. http://faostat.fao.org/site/567.

FAO-Unesco. 1988. Soil Map of the World, revised legend with correction. World soil resources report 60. FAO, Rome, Italy. pp. 140.

Gamie O.A. 2007. Effect of planting methods and planting densities on establishment, growth, yield and quality of garlic bulbs. MSc thesis submitted to the school of graduate studies, University of Asmara, Asmara, Eritrea.

Goldy R. 2000. Producing Garlic in Michigan. Extension Bulleting E-2722, Michigan State University Extension.

Hell D.S. and Waller J.M. 1994. Pest and diseases of tropical crops. Field hand book. Longman group, UK Ltd.

Janet B. and Tammy, H. 2008. Garlic: Organic production. www.attra.ncat.org/attra-pub.

Kero J. 2010. Survey and serological identification of viruses infecting garlic in Ethiopia. MSc thesis submitted to Addis Ababa University, Addis Ababa, Ethiopia.

Lawson L. D. 1996. Garlic: a review of its medicinal effects and indicated active compounds. In L. D. Lawson, & R. Bauer (Eds.), Phytomedicines of Europe: Their chemistry and biological activity (pp. 176-209). Washington DC: ASC Press.

Ministry of Agriculture. 2005. Vegetable crops research program. Annual report of National Agricultural Research Institute. Halhale, Eritrea.

Ministry of Agriculture. 2011. Annual Report. Horticulture Division Report, Asmara, Eritrea.

Ministry of Agriculture. 2015. Horticulture Division Annual Report, Asmara, Eritrea.

Ministry of Agriculture. 2016. Horticulture Division Annual Report. Southern Region Branch, Mendefera, Eritrea

Ministry of Finance. 2007. Import Commodity. Customs Department, Research and Statistic division. In Gamie, O.A. 2007. Effect of planting methods and planting densities on establishment, growth, yield and quality of garlic bulbs. MSc thesis submitted to the school of graduate studies, University of Asmara, Asmara, Eritrea.

Muriithi M.M. and Irungu J.W. 2004. Effect of integrated use of inorganic fertilizer and organic manures on Bacterial Wilt Incidence (BWI) and tuber yield in potato production systems on hill slopes of central Kenya. J. Mountain Sci. 1: 81-88. http://dx.doi.org/10.1007/BF02919363.

Nagy M., Socaci S.A., Tofana M., Pop C., Muresan C., Pop A., Salanta L. and Rotar A.M. 2015. Determination of Total Phenolics, ntioxidant Capacity and Antimicrobial Activity of Selected Aromatic Spices. Bulletin UASVM Food Science and Technology. 72(1).

Negassi A., Bein E., Ghebru K. and Tengnäs B. 2002. Soil and Water Conservation Manual for Eritrea. RELMA Technical Hand-book No. 29. Regional Land Management Unit, Swedish International Development Cooperation Agency. Nairobi, Kenya.

Olkowski W., Daar S. and Olkowski H. 1995. The gardener's guides to common-sense pest control, The Taunton Press, USA.

Rader H. and McGuinness J. 2015. Growing Garlic in Alaska. HGA-00047. University of Alaska Fairbanks. www.uaf.edu/ces or 1-877-520-5211.

Rana M.K. 2008. Garlic. In Rana, M.K. (ed). 2008. Olericulture in india. Kalyani Publishers, Ludiana; India. pp. 459-487.

Roling, N. 1988. Extension Science: Information system in agricultural development. Cambridge University Press; Cambridge, Great Britain.

Saleh B. K., Nyende A. B., Kasili R., Mamati E. and Araia W. 2013. Current Status and Future Opportunities of Pepper Production in Eritrea. ARPN Journal of Agricultural and Biological Science. 8(9): 655-672.

Shinde N.N., Sanyal D. and Sontakke M.B. 2003. Garlic. In Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G. (Eds). Vegetable crops. 3rd edn, vol. 3. Parth Sankar Basu, Kalkata, India. pp. 121-178.

Steferud, A. 2010. Diseases of vegetable crops. Biotech Books publishing agency, Delhi, India.

Stillhardt B., Ghebru B. and Haile A.M 2003. Small-scale Micro Irrigation in Eritrea: A feasibility study on the introduction of affordable micro irrigation technology in Eritrea.

Thind T.S. and Jhooty J.S. 1982. Association of thrips with purple blotch infection on onion plants caused by *Alternaria porri*. Indian phythopathology. 35: 696-698.

Tsai C.W., Chen H.W., Sheen L.Y. and Lii. C.K. 2012. Garlic: Health benefits and actions. Bio-Medicine 2(1): 17-29.

Wiczkowski, W. 2011. Garlic and Onion: Production, Biochemistry, and Processing. In Sinha, N. K. (ed). Hand book of vegetables and vegetable processing. Blackwell Publishing Ltd. pp. 625-642.