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CURRENT STATUS AND FUTURE OPPORTUNITIES OF PEPPER PRODUCTION IN ERITREA

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ABSTRACT

Pepper has been grown in Eritrea for a very long period. The crop was well utilized during the 1950s up to 1970s when the export demand was high. Currently yield per hectare of pepper is continuing to decline from 10.6 t/ha in 2008 to 4t/ha in 2011. A study was conducted in 10 major pepper growing sub-regions located in four regions for determining the major constraints and opportunities of pepper production in Eritrea. A participatory rural appraisal method that included collection of secondary data, key informants interviews, focus group discussions and formal household survey was used. The major constraints identified were unavailability of improved and quality seed, inputs and services, insect pests and diseases, small acreage and discouraging land tenure system, improper marketing chain, poor extension service and persistent drought that affect water availability. Opportunities are availability of vast lands, favourable climate, domestic and export markets and experienced farmers with high willingness to grow pepper. The results of the study show that average family size was 8.2±3.2, working members of the family were 3±2.2 and male to female ratio was 1.1:1. The age of the respondents ranged from 24-86 with average of 53.2±13.5 years and 98% of the interviewed households were man headed. Respondents who had formal education were 73% and illiterate 15.9% while 11% could read and write. Experience in growing pepper ranged from 1 to 66 years with average of 16.4±13.8. Cereals and vegetables producers comprised 49.5% of the respondents while 31.3% were active in vegetable production. The percentage of respondents growing green pepper was 40.7%, dry pepper 25.8% and both types 33.5%. Average land size was 3.66±8.1ha and area allotted to pepper 1±2.22. Farmers who kept their own seed were 69.2% and those who produced their own seedlings are 82.4%. Days from sowing to transplanting ranged from 20-90days with average of 44±13 days. Majority of farmers (86.3%) grow pepper once a year, 73.6% of them plough the land 2 or 3 times, 51.6% use animal driven equipments for plough and 83.5% transplant into narrow ridge. Average spacing between rows was 51.4±13.2cm and between plants in row was 29.6±12.2 resulting in 51, 154 plants/ha. Majority of the farmers applied fertilizers. The percentage of respondents who applied organic and mineral fertilizers was 76.9% and 70.9% respectively; however, the amount is far below the recommended. Severity of insect pests, diseases and weed problems were found to be 58.8, 56.6 and 42.3% respectively. Eritrea has great potential for pepper production however, constraints need to be overcome and opportunities maximized.

Keywords: Eritrea, local pepper, production, sub-region, respondents, constraints.

INTRODUCTION

Pepper have been grown and used in Eritrea for very long time but there is no literature on the exact time when it was introduced in Eritrea. It is believed that it was introduced during the Italian colonial period betwenn1891 and 1940, however, some elder farmers born in the 1920's mentioned that they know pepper from their childhood and their fathers and grandfathers have been growing it and it is the sweet pepper that was introduced by the Italians. It was common practice of farmers to grow pepper near to their houses or in a small fenced land in the field of cereals called locally *Grat-berber* (pepper plot). The produce was mainly for home consumption; however, surplus was directed to the market. During the 1950s to mid 1970s Eritrea was exporting green peppers to Europe and the Middle East. Report of the Bank of Ethiopia (1962) mentioned that there was great increase in green pepper production in the previous years due to high demand for export. The Annual agricultural reports of Ethiopia (1957-1960 and 1969) show that, the production of green pepper increased greatly from 99 tons in 1957 to 8, 482 tons in 1968 (Table-20).

Pepper is one of the important vegetable crops of Eritrea as well as the world. The 2010 Food and Agriculture Organization of the UN (FAO) statistics show that the world cultivated area with dry and green peppers is approximately 1.92 and 1.86 million hectares respectively and the total production was 3.06 million tons of dry and 27.55 million tons of green pepper, with average yield per ha of 1.6 tons of dry 14.8 tons green peppers. Similarly in Africa the total cultivated area was 618, 478 ha of dry and 358,320 of green peppers that produced 536, 657 tons of dry and 2.9 million of green peppers respectively with average yield/ha of 0.86 tons dry and 7.49 tons green peppers (FAOSTAT, 2012).

In East Africa Ethiopia is by far the most important producer of both dry and green peppers, however, it was the lowest in yield/ha for both green and dry peppers. While Sudan and Kenya recorded the highest yield/ha for green and dry peppers respectively (FAOSTAT, 2012).

In Eritrea the statistics (Ministry of Agriculture of 2010) show that the crop was ranked second after tomato in the cultivated area among the most widely grown vegetable crops in Eritrea, but it was ranked fourth in

production following tomato, onion and potato. The total cultivated area under pepper in 2011 was 4, 132 ha and the production 15, 118 tons with average yield of 3.7 tons/ha (MoA, 2012). In the last ten years, Eritrea has shown continuous increase in both cultivated land and production. The cultivated land increased from 1093 ha in 2003 to 4, 132 ha in 2011. Similarly the production increased from 11, 021 tons to 15, 118 tons, while the productivity greatly declined from 10.1 t/ ha in 2003 to 7.3 t/ha in 2010, and 4 t/ha in 2011 (MoA, 2012). Comparing to some of the neighbouring Eastern Africa countries the production may still look good. However it is far below the world averages (MoA, 2012 and FAOSTAT, 2012).

Though dominating as a hot spice, pepper has a variety of uses, either consumed fresh or cooked/preserved and dried, used as food dye, bred as ornamental plants and also to provide the important ingredient capsaicin for the drug/chemical industry (Djian-Caporalino *et al*., 2006). Pepper is an ingredient in preparation of most Eritrean dishes. The green pods are eaten raw as a salad or appetizer while the dry red pods are ground into powder called '*berbere'*. In addition dry red pods are the main component for preparing *shiro* powder, which is a popular sauce in Eritrea. Based on survey conducted in 2002 by the National Office of Statistics, the average weekly household consumption of dry pepper in Eritrea is estimated by 140 grams. Pepper also has high potential for the export market.

Pepper is important for the daily use of Eritreans. This is to say positive or negative changes in the supply of this commodity to markets and its quality will affect the prices and in turn will affect the consumer. On the other hand majority of pepper growers in Eritrea are small scale farmers. Thus large numbers of farmers are affected by the low productivity and quality of the pepper they grow.

Only a small amount of the pepper consumed in Eritrea is produced locally and mainly consumed as fresh pods. The bulk of the dry pepper is imported demanding big amount of foreign currency and creating scarcity and price escalation in many occasions. Attempts are going on to substitute the imported pepper with locally produced ones. However, yield and quality of the locally produced pepper is still quite low.

Several factors are contributing to result the low yield and quality of pepper produced in Eritrea affecting both the producers and consumers. However, information regarding constraints and opportunities is not available. Asgedom *et al*., 2011 stated that in Eritrea, the few surveys conducted in the past, were basically very general and covered all horticultural crops. Such surveys did not identify current status, constraints and opportunities at the crop level. Thus the current study was conducted in order to identify constraints and opportunities of pepper production in order to make informed decisions that may help find solutions for the major constraints and maximize the use of opportunities for improving pepper production and quality in Eritrea. The objective of this study is document the current status and opportunities of pepper production in Eritrea.

MATERIALS AND METHODS

Location

The study was conducted in four administrative regions of Eritrea. The regions surveyed were Southern or Debub (4 sub-regions), Anseba (2 sub-regions), Northern Red Sea (3 sub-regions) and Gash-Barka (1 sub-region). Survey locations and number of respondents in each region and sub-region were determined based on number of farmers and analysis of information about history and current pepper growing areas in Eritrea. Agro-climatic regions coverage was also considered (Table-1). Tekreret of Anseba and Sawa of Gash-Barka sub-regions that are currently important areas of commercial dry pepper production were not covered in the current study due to logistical challenges.

Table-1. Surveyed sub-regions number of respondents and participants in group discussions.

Region	Sub-region	Agro-climatic regions	Number of respondents	Participants in focus group discussions
Anseba	Elabered	Western escarpment	18	8
	Geleb	Northern central highlands	16	15
Southern (Debub)	Mendefera	Southern central highlands	19	13
	Dbarwa	Southern central highlands	20	14
	Adi-quala	Western escarpment	11	-
	Dekemhare	Southern central highlands	17	13
Northern Red Sea	Foro	Coastal plains	14	12
	Gindae	Green belt and coastal plains	32	12
	Afabet	Northern central highlands	20	10
Gash-Barka	Akurdat	Western lowlands	15	10
Total			**182**	**107**

Secondary data

Published and non-published documents on pepper production and related topics that would help in analysing the current situation and future prospects of pepper production in Eritrea were collected. Information was collected from the Ministry of Agriculture Headquarters and the regional offices, National Agricultural Research Institute, Ministry of Trade and Industry, Department of Customs and National Office of Statistics. The collected data included policies and regulations in agriculture and import export guidelines, production areas, introduced varieties, seed and inputs distribution, pepper quantity produced locally, value of imported pepper, pepper consumption and annual reports, projects and consultancy reports (Annex B).

Key informant discussions

A total of 25 interviews were conducted with key informants familiar with pepper production. The interviewed experts were staff of the Ministry of Agriculture headquarters, staff of the Ministry of Agriculture regional and sub-regional offices, Staff of the National Agricultural Research Institute and experts in other organizations (Annex A). A check list was used to initiate and guide the discussion but a free flow was allowed for extracting as much information as possible. The discussion focused on the major issues of pepper production in the country or specific places such as history and development of pepper production, current trend, and major factors affecting production

Focus group discussions

Nine focus group discussions were held in nine of the ten sub-regions surveyed. The discussions included farmers of different age groups and some extension workers. The number of participants in each discussion was in the range of 8-15 participants (Table-1). Number of participants in each group was decided based on consultation with staff of Ministry of Agriculture in each region and sub region, and resources available. A check list was used to guide the discussion but was conducted in informal way to encourage free flow of discussion. The discussions mainly focused on pepper production history and development and current constraints and opportunities of pepper production at farmer level.

Formal household surveys

Surveys were conducted in selected major hot pepper growing areas. Based on previously collected information and discussions with staff of the Ministry of Agriculture in the region, the most important pepper growing sub-region and areas within sub-region were selected. Thereafter, farmers in each area were randomly selected. A formal semi-structured questionnaire was used for collecting data at individual farmer level. Number of farmers to be interviewed in each area was determined based on number of producers in the area. The head of the household was the person interviewed.

Data collection and analysis

Data collected included general information about farmers, cultivated areas, varieties in use, source of seed, application of different cultural practices, yields, cost and availability of inputs, marketing of products, prices, and distances to markets, major constraints and opportunities.

Nokia E5 mobile and HP Pavilion 6 laptop were used to record the interviews of the key informants and the focus group discussion respectively to avoid information leakage.

Excel 2010 was used for arranging the quantitative data collected in form of frequencies, percentages and averages. The qualitative data from the interviews and discussions as well as the secondary sources was subject to logical analysis for supporting the quantitative data analysis.

RESULTS AND DISCUSSIONS

Gender and household characteristics

Average family size in the surveyed areas was 8.2±3.2 persons per family with the highest being 10.3±4.5 and 9.9±3.9 in Afabet and Geleb respectively, while the lowest was 6.6±2.7 in Gindae (Table-3). The high average number of persons per family in the two sub-regions could be due to majority of the respondents in Afabet and many in Geleb had more than one wife. However, the general high average in the surveyed areas is due to social and economical factors that appreciate large families and members are source for farm labour. The results in Table-2 also show the higher average number of male members compared to female members in the family. This is slightly different from the United Nations report of 2004, which shows that in 2003 the male to female ratio in Eritrea was 1: 1.01. The results in Table-2 show an over-all of 1.1:1 male to female ratio with the highest in Geleb (1.48:1) and the lowest in 0.96:1 in Dbarwa and 0.98:1 in Afabet.

Average number of working persons in the family was 3±2.2. The highest was 4.5±4.4 in Adi-quala and the lowest was 2±1.5 in Afabet and Akurdat. The participation of women in farming activities was evident. Average number of working female members of the family was 0.85±1.3 with the highest 1.5±2.7 persons in Adiquala and lowest 0.14±0.5 and 0.14±0.4 in Foro and Akurdat respectively (Table-2). It was observed that women participation in farm work was lower in sub-regions Foro, Afabet, Akurdat and Geleb where women usually do house work and girls may participate in herding goats and sheep. This is in agreement with (Green and Baden, 1994) who reported that gender division of labour in Eritrea is affected by agro-ecological, socio-cultural and socio-economic factors. They explained that women participation in farm work is less in the semi-nomads Muslim communities of the lowlands compared the Christian communities of the southern highlands who practice settled agriculture.

The results show that 98% of the households were headed by man. The lowest percentage (93.8%) was

in Gindae and the highest (100%) in seven of the surveyed sub-regions (Table-3). This shows that households in rural areas are man dominated. The 2% women headed households are mainly due to being widowed (data not shown).

Table-2. Mean family size, number of working persons and children in school.

	Family size				Number of working persons		
Sub-region	**Male**	**Female**	**Total**	**M to F ratio**	**Male**	**Female**	**Total**
Elabered	3.8±1.8	3±2	6.8±3.1	1.27:1	1.9±1.3	1.2±1.8	3.1±2.4
Geleb	5.9±2.8	4±1.6	9.9±3.9	1.48:1	2.2±1.4	0.6±0.9	2.8±2.2
Mendefera	4.1±1.7	3.3±1.42	7.4±2.3	1.24:1	2.4±1.4	1.4±1.1	3.8±1.9
Dbarwa	4.6±1.9	4.8±1.9	9.4±2.3	0.96:1	2.4±1.4	1.3±1.5	3.7±2.2
Adi-quala	5±1.7	5±1.7	10±2.7	1:1	3±2	1.5±2.7	4.5±4.4
Dekemhare	3.9±1.7	3.6±1.7	7.5±2.6	1.08:1	2.1±1.2	1.1±0.9	3.2±1.7
Foro	4.1±1.8	3±2.3	7.1±2.7	1.37:1	2.2±1	0.14±0.5	2.3±1.3
Gindae	3.3±1.7	3.3±1.6	6.6±2.7	1:1	1.5±0.9	0.7±1	2.2±1.5
Afabet	5.1±1.8	5.2±3.5	10.3±4.5	0.98:1	1.7±1	0.3±1	2±1.5
Akurdat	4.5±2.4	3.5±1.1	8.0±2.8	1.29:1	1.9±1.4	0.14±0.4	2±1.5
Grand mean	**4.3**	**3.9**	**8.2**	**1.1:1**	**2.1**	***0.85***	**3.0**

The age of the respondents ranged from 24 to 86 with average of 53.2±13.5 years (data not shown). The results also show that 41.2% of the respondents were in the age range of 50- 64 years; 22%, 65 years or greater including elders greater than 75 years old and only 1.6 % less than 30 years. The highest percentage (65%) of the age group 50-64 was in Afabet and the lowest (31.6%) in Mendefera, while age group (65 years or greater) was higher (42.1%) in Mendefera compared to the lowest (7.1%) in Foro (Table-3). This indicates that most of the respondents are in the last active age stage or even beyond the active age. It indicates also that young people are somewhat away from farm work. The reason partially could be due to young people have more tendencies to move out of agriculture, but it is mainly due to engaging them in military service. This could be one of the main reasons for the unavailability and high labour cost considered in some of the surveyed areas as one of the production constraints.

Education is an important tool for development. Particularly in agriculture it is important for farmers to understand and adopt improved technologies that ultimately lead to higher yield and better product quality. The result of the current study show that 15.9% of the respondents are illiterate, 11% can read and write and 73 % had formal education. The highest percentage of respondents who had no formal education was in Afabet (85%) and the lowest (5.9%) was in Dekemhare (Table-3). The high percentage in Afabet is due to the pepper production area in this sub-region had no access to school until very recent years. The percentage of farmers who had formal education was higher than that of tomato growers reported by Asgedom *et al*., 2011. National literacy rate in Eritrea is 67% and male and female literacy rates are 73.6 and 56.3% respectively (UNESCO, 2012). Since 98% of the respondents in the current study are male, the results in agreement with that of UNESCO 2012 who also indicated wide disparity among the different regions and between male and female. Disparity among regions can be observed in Table-3, while differences between male and female can be observed in the number of children going to

Table-3. Gender, educational level and age groups of the respondents.

	Gender		**Education level**							**Age groups** (year)					
Sub-region	**M** (%)	**F** (%)	**Ill** (%)	**RW** (%)	**P** (%)	**J** (%)	**S** (%)	**C** (%)	**G** (%)	**< 30** (%)	30-39 (%)	**40-49** (%)	**50-64** (%)	**=>65** (%)	**N**
Elabered	94.4	5.6	27.8	5.6	33.3	11.1	16.7	5.6	0.0	0	22.2	5.6	44.4	27.8	18
Geleb	100	0	6.3	6.3	56.3	6.3	12.5	6.3	6.3	0	6.3	25.0	50.0	18.8	16
Mendefera	100	0	15.8	0.0	47.4	0.0	31.6	0.0	5.3	0	15.8	10.5	31.6	42.1	19
Dbarwa	100	0	9.1	9.1	81.8	36.4	18.2	0.0	0.0	0	0.0	18.2	54.5	27.3	11
Adi-quala	100	0	20.0	5.0	10.0	20.0	15.0	0.0	0.0	0	0.0	40.0	35.0	25	20
Dekemhare	94.1	5.9	5.9	0.0	52.9	17.6	17.6	5.9	0.0	0	29.4	17.6	35.3	17.6	17
Foro	100	0	28.6	0.0	50.0	14.3	7.1	0.0	0.0	7.1	7.1	42.9	35.7	7.1	14
Gindae	93.8	6.3	15.6	6.3	28.1	12.5	25.0	3.1	9.4	6.3	21.9	21.9	31.3	18.8	32
Afabet	100	0	20	65	5.0	10.0	0.0	0.0	0.0	0	0.0	15.0	65.0	20	20
Akurdat	100	0	6.7	6.7	40.0	6.7	26.7	6.7	6.7	0	6.7	40.0	40.0	13.3	15
Total	**98**	**2.0**	**15.9**	**11.0**	**36.8**	**12.6**	**17.6**	**2.7**	**3.3**	**1.6**	**12.1**	**23.1**	**41.2**	**22.0**	**182**

school. Average number of male children going to school was 1.7 compared to 1.3 of female children. The results also show that only 6% of respondents have education greater than high school which indicates that people beyond the high secondary school usually do not go for farm work; instead they prefer to be employed by the government or other employers. This is similar to that found by Mariyono, *et al*., 2009 who reported that in Central Java; very highly educated farmers prefer to go to more comfortable business than to be engaged in labour intensive chilli production.

Farming activity and experience

Different farming activities are employed in the surveyed areas for income generation. The results in Table-4 shows that 49.5% of the respondents were active in vegetable and cereals production, while 31.3% were vegetable growers and only 1.1% were engaged in outside farm activities. The highest percentage (100%) of cereals and vegetables producers was in Mendefera and Dbarwa and the lowest (0%) was in Akurdat. The highest for vegetable producers (65%) was in Afabet and the lowest (0%) in Mendefera and Dbarwa (Table-5). Akurdat recorded the highest percentage of respondents engaged in fruit and vegetable production (66.7%) and vegetable, fruit, vegetables and cereals (20%), while the lowest (0%) for the former was in Mendefera, Adi-quala, Dbarwa and Foro and for the later in seven sub-regions. The reason is Akurdat is a centre for banana production while in most of the southern region areas fruit production is not common.

Farmers in Eritrea have long history of pepper production. Experience in pepper production of the respondents ranged from 1 to 66 years and the average was 16.4±13.8 years (data not shown). The results show that 51.1% of the respondents had less than 10 years experience with the highest in Foro (100%) followed by Afabet (85%) which are new pepper growing areas, while the lowest was in Mendefera (5.3%) which one of the oldest pepper production areas in the country (Table-4). The results also show that 7.9% and 3.4% are in the 36-50 and >50 years category indicating to long history of pepper and more engagement of old people in production.

Table-4. Income generating activities and experience in pepper production.

	Income generating activity					**Experience**						
Sub-region	**Veg** %	**C and veg** %	**Fr. and veg** %	**Veg, Fr. and C** %	**Other** %	**10 <=** (%)	**11-15** %	**16-25** %	**26-35** %	**36-50** %	**> 50** %	**N**
Elabered	44.4	22.2	33.3	0.0	0.0	29.4	17.6	23.5	17.6	5.9	5.9	17
Geleb	25.0	18.8	50	6.3	0.0	68.8	18.8	12.5	0.0	0.0	0.0	16
Mendefera	0.0	100	0.0	0.0	0.0	5.3	10.5	26.3	21.1	21.1	15.8	19
Adi-quala	30.0	65	0.0	5.0	0.0	15.8	10.5	31.6	42.1	0.0	0.0	19
Dbarwa	0.0	100	0.0	0.0	0.0	63.6	36.4	0.0	0.0	0.0	0.0	11
Dekemhare	35.3	58.8	5.9	0.0	0.0	41.2	0.0	17.6	11.8	29.4	0.0	17
Foro	50.0	50	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	14
Gindae	34.4	56.3	6.3	0.0	3.1	63.4	3.3	20.0	3.3	6.7	3.3	30
Afabet	65	25	5.0	0.0	5.0	85	15.0	0.0	0.0	0.0	0.0	20
Akurdat	13.3	0.0	66.7	20.0	0.0	46.6	6.7	26.7	0.0	13.3	6.7	15
Grand mean	**31.3**	**49.5**	**15.4**	**2.7**	**1.1**	**51.1**	**10.7**	**16.9**	**10.1**	**7.9**	**3.4**	**178**

Acreage and area allotted for pepper

Land size is an important component in expansion and increased production of any crop. Generally in Eritrea acreage is very small, however, in lowlands it is larger compared to the highlands and midlands. The result of the current study show that average land size of the surveyed area is 3.66±8.1 ha with minimum land size of 0.025 ha in Afabet and maximum of 85 ha in Akurdat. The highest land size was in Akurdat (14.28 ± 20.7 ha) and the lowest (1.1±1.7 ha) in Afabet (Table-5). The small land size in Afabet is specifically for villages along the Mogae River which is the pepper growing area of Afabet, while in the upper lands of the sub-zoba larger land sizes could exist.

Average area allotted for pepper is 1±2.2 ha with minimum of 0.015 ha in Afabet and maximum of 25 ha in Gindae. The highest average area allotted (2.31±4.7) for pepper was in Gindae and the lowest (02±0.1) was in Geleb (Table-5). This is almost similar to that mentioned by Grubben and El Tahir, (2004) who stated that in Africa capsicum production is usually practised on small-scale farms on plots of 0.1-0.5 ha, but much smaller than the average reported by Asgedom *et at*., (2011) for tomato growers in Eritrea (3.26 ha). Cereals, tomato, potato, onion, fruits and some other minor vegetables are competitors of pepper in farm land. The degree of competition between pepper and the other crops varies from place to place. Total acreage depends on availability of cultivable land and population density, while allocation of land to different crops depend on farmers decision depending on the importance of each crop as household food or cash crop and its adaptability to the conditions of the area. Mariyono, *et al*. (2009) found farmers who had large land size allotted larger area for pepper compared to those had smaller land. This is somewhat true for the current study where farmers with large acreage tend to grow larger area of pepper, except in Akurdat where greater attention is given to banana, onion and may be other vegetables such as pumpkin (Table-5).

Table-5. Mean acreage and area allotted for pepper compared to other crops.

	Total farm area (ha)			**Area allotted for pepper** (ha)			**Mean area allotted for competing crops** (ha)					
Sub-region	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Tomato**	**Potato**	**Onion**	**Other veg.**	**Cereals**	**Fruits**
Elabered	1.72	5.8	1	0.23	0.5	0.1	0.58	0	0.05	0	0.36	0.36
Geleb	1.77	4	0.5	0.2	0.5	0.1	0.4	0.34	0.4	0.06	0.26	0.38
Mendefera	2.92	6.5	0.5	0.56	2	0.1	0.46	0.86	0.12	0.56	1.36	0
Dbarwa	3.6	8	1	0.74	3.5	0.125	0.86	0.88	0.32	0.74	1.07	0.003
Adi-quala	1.55	3	0.5	0.24	0.75	0.125	0.26	0.26	0.1	0.13	1.32	0
Dekemhare	2.4	5	1	0.53	1	0.25	0.65	0.49	0	0.35	0.61	0.05
Foro	2.93	12	0.5	1.91	7	0.5	0.16	0.002	0.12	0.21	0.47	0
Gindae	4.8	50	0.25	2.31	25	0.1	0.48	0	0	0.1	0.63	0.2
Afabet	1.1	7.5	0.025	0.7	2	0.015	0.05	0.005	0.05	0.03	0.32	0.01
Akurdat	14.28	85	3	1.45	3.5	0.25	1.73	0	1.33	1.3	1.55	3.1
Grand mean	**3.7**	**85.0**	**0.025**	**1.0**	**25.0**	**0.015**	**0.58**	**0.28**	**0.22**	**0.33**	**0.76**	**1.22**

Pepper varieties and seed source

Generally pepper grown in Eritrea is for both green (fresh) and dry consumption. The result show that farmers know cultivars or types suitable for dry or green peppers, but most of them (77.5%) could not mention the name of the variety under cultivation. Even the mentioned names are not real variety names but the place where they came from (Sawa or Adis), the shape of fruit (Kerni-irab) or the organization that introduced it (Amrach). The highest percentage of farmers who do not know name of varieties they grow was in Geleb (100%) and the lowest (40%) in Dbarwa (Table-6). The reason for the high percentage for not knowing the variety name could be due to in the last 20 years there was no introduction of new varieties or seed distributions for pepper resulting in most of the farmers (69.2%) use their own seed or purchase seed of unknown quality from other farmers or consumption market (26.9%).

Table-6. Knowing of varieties grown, seed source and type of pepper production.

	Knowledge of variety grown		Seed source			Production type				
Sub-region	**Yes** (%)	**No** (%)	**Own seed** (%)	**Purc-hased** (%)	**Seed exch-ange** (%)	**Green** (%)	**Dry** (%)	**Green and dry the same crop** (%)	**Green and dry separate fields %**	**N**
Elabered	11.1	88.9	66.7	22.2	11.1	44.4	22.2	33.3	0.0	18
Geleb	0.0	100	25	56.3	18.8	68.8	25.0	6.3	0.0	16
Mendefera	31.6	68.4	94.7	5.3	0.0	52.6	0.0	42.1	5.3	19
Dbarwa	60.0	40	75	25.0	0.0	63.6	0.0	36.4	0.0	11
Adi-quala	45.5	54.5	27.3	72.7	0.0	40.0	10.0	10.0	40.0	20
Dekemhare	23.5	76.5	94.1	0.0	5.9	41.2	5.9	41.2	11.8	17
Foro	28.6	71.4	50	50	0.0	7.1	50.0	14.3	28.6	14
Gindae	12.5	87.5	90.6	9.4	0.0	65.6	9.4	15.6	9.4	32
Afabet	15.0	85	85	10.0	5.0	0.0	95.0	5.0	0.0	20
Akurdat	6.7	93.3	33.3	66.7	0.0	6.7	46.7	40.0	6.7	15
Grand mean	**22.5**	**77.5**	**69.2**	**26.9**	**3.8**	**40.7**	**25.8**	**23.1**	**10.4**	**182**

Although dry pepper is more consumed in Eritrea, until recent years its production was limited compared to green pepper. The results in Table-6 are in agreement with that. It shows that 40.7% of the respondents produce green pepper, 25.8% dry pepper and 33.5% both green and dry peppers either in separate plots (10.4%) or successively from the same crop (23.1%). This is a mechanism for earning early income. The highest green pepper producers (68.8%) were in Geleb and the lowest (0%) in Afabet, while for dry pepper the highest was in Afabet (95%) and the lowest (0%) in Mendefera and Dbarwa.

Seedling quality is one of the most important factors that affect productivity. In agreement with Grubben and El Tahir, (2004) who stated that direct seeding in pepper is rarely practiced, all the respondents use seedling method for growing pepper (data not shown). The results in Table-7 show that majority of the respondents (82.4%) produce their own seedlings compared to 8.8% who purchase seedlings and 8.8% who produce their own seedlings or sometimes purchase. The highest percentage of farmers who produce their own seedlings (100%) was in Dekemhare, Gindae and Akurdat, while the lowest was in Adi-quala (36.4%). Currently the sources of seedlings available for sale are the surplus from farmers. Information from the key informants and focus group discussions show that no specialized nurseries that produce quality seedlings for sale are available. During the 1990s the Ministry of Agriculture used to produce seedlings and sale them to farmers at reasonable price. Figure-1 shows that farmers usually use beds on a plot in the middle or one side of the field to be used as nursery which may affect the health of the seedlings produced due to infection from the surrounding field.

Table-7. Source of seedlings and number of days to transplant.

	Source of seedlings			Days to transplant					
Sub-region	**Own seedlings** (%)	**Purchase** (%)	**Sometimes purchase** (%)	**30** (%)	**35-40** (%)	**45-55** (%)	**60** (%)	**Other** (%)	**N**
Elabered	88.9	11.1	0.0	33.3	44.4	22.2	0	0	18
Geleb	75	25	0.0	50	18.8	31.3	0	0	16
Mendefera	63.2	5.3	31.6	0	0.0	5.3	78.9	15.8	19
Adi-quala	36.4	54.5	9.1	0	15	20	30	35	20
Dbarwa	90	5	5	9.1	9.1	0	72.7	9.1	11
Dekemhare	100	0	0	5.9	0	41.2	41.2	11.8	17
Foro	50	14.3	35.7	64.3	14.3	7.1	7.1	7.1	14
Gindae	100	0	0	56.3	12.5	12.5	0	18.8	32
Afabet	85	0	15	25	10	50	5	10	20
Akurdat	100	0	0	33.3	26.7	33.3	0	6.7	15
Grand mean	**82.4**	**8.8**	**8.8**	**29.1**	**14.8**	**22.5**	**20.9**	**12.6**	**182**

Age of the seedling is an important quality factor. The number of days from sowing to transplanting practiced by the respondents has ranged from 20 days in Gindae to 90 days in Mendefera and Adi-quala with average of 44±13 days (data not shown). The Asian Vegetable Research and Development Canter's (AVRDC)

suggested cultural practices for chilli pepper (Berke *et al*., 1999) consider 30 days after sowing are optimum for transplanting under favourable conditions. At this age seedlings form 4 to 5 leaves. Grubben and El Tahir, (2004) consider transplanting 30-40 days old seedlings with 8 to 10 leaves as usual in tropical regions. Only 29.1% of the respondents in the current study transplant seedlings at 30 days after sowing, while 14.8% transplant 35-40 days after transplanting. A total of 54.3% of the respondents found to transplant above 45 days and out of them 12.6% are even transplant at the age greater than 60 days (Table-7). This implies that aged seedlings used are difficult to establish and be productive (Figure-1). This could be the reason for several replanting mentioned by farmers in these areas.

Growing seasons and land preparation

Selection of growing season depends on climatic conditions, availability of water, market, pests and other factors. In Eritrean highlands and midlands pepper can be grown at least two times per year. However, the results of the current study show that 86.3% of the farmers grow pepper once a year. The highest was 100% in Gindae, Afaabet and Akurdat and the lowest 60% in Dbarwa (Table-8). Discussions with farmers and key informants revealed that shortage of irrigation water is the major reason for not growing second season.

Land preparation for pepper should include enough tillage that enables seedlings to establish well and provide proper soil texture for root growth and development (Kelley and Boyhan, 2006). Most of the respondents consider land preparation an important practice for getting good yield and protecting plants against soil borne diseases. The results of the current study show that 35.7% and 37.9% of the respondents plough the land 2 or 3 times respectively and only 4.9% plough their land once. The highest for ploughing 3 times was 90.9% in Adi-quala and the lowest was 5.9% in Dekemhare, while the highest for one plough was 30% in Afabet (Table-8). This shows how much the farmers consider repeated plough important for their crop.

Animal driven plough equipment is the most widely used method in the surveyed areas. It is used by 51.6% of the respondents. Tractor users constitute 23.7% while 24.7% of the respondents use both tractor and animal driven equipment. The highest users of animal driven equipments were in Afabet (100%) and the lowest (3.1%) in Gindae (Table-8). The reason for dependency on animals for plough in the highlands and midlands is mainly due to small land size unsuitable for large tractors which are common in Eritrea, while in the lowlands shortages of tractor services is the problem.

Prior to transplanting farmers divide the land into smaller plots and start preparing the ridges where pepper plants are to be planted. The results show that majority of the respondents (83.5%) plant pepper in narrow ridges which is common in Eritrea for solanacious crops. The highest was 100% found in Elabered, Adi-quala, Dekemhare and Foro, while the lowest (20%) was in Afabet. Other variations in bed preparation are basin (4.9%), flat ridge (6.6%) in addition to zigzag narrow ridge locally known as Sebaa-Themanya method (4.9%) which is common in Afabet only (Table-9).

Table-8. Number of pepper growing seasons, number of plough and plough methods.

	Number of seasons per year		**Number of ploughs**					**Plough method**			
Sub-region	**One** (%)	**Two** (%)	**1** (%)	**2** (%)	**3** (%)	**4** (%)	**5** (%)	**AD** (%)	**TR** (%)	**AD and TR** (%)	**N**
Elabered	94.4	5.6	0.0	44.4	50.0	5.6	0.0	77.8	16.7	5.6	18
Geleb	81.3	18.8	0.0	43.8	56.3	0.0	0.0	93.8	6.3	0.0	16
Mendefera	73.7	26.3	0.0	20.0	25.0	50.0	5.0	25.0	25.0	45	20
Dbarwa	60	40	0.0	0.0	52.6	31.6	15.8	68.4	10.5	26.3	19
Adi-quala	72.7	27.3	0.0	0.0	90.9	9.1	0.0	72.7	27.3	0.0	11
Dekemhare	76.5	23.5	0.0	0.0	5.9	41.2	52.9	35.3	0.0	64.7	17
Foro	100	0.0	0.0	57.1	42.9	0.0	0.0	78.6	0.0	21.4	14
Gindae	96.9	3.1	9.4	62.5	28.1	0.0	0.0	3.1	53.1	43.8	32
Afabet	100	0.0	30.0	60.0	10.0	0.0	0.0	100	0.0	0.0	20
Akurdat	100	0.0	0.0	40.0	53.3	0.0	6.7	6.7	80	13.3	15
Grand mean	**86.3**	**13.7**	**4.9**	**35.7**	**37.9**	**13.7**	**7.7**	**51.6**	**23.6**	**24.7**	**182**

The results in Table-9 show that most of the respondents (65.9%) apply specific intra and inter-row spacing. The highest (90.9%) was in Adi-quala and the lowest (20%) in Afabet. Average spacing between rows was 51.4±13.2 cm and between plants in row 29.6±12.2 cm. The highest average spacing between rows (77.5±26.3cm) was in Afabet and the lowest (46.5±8.8cm) in Adi-quala, while the highest spacing between plants in row (60 cm) was in Afabet and the lowest (21.3cm) in Elabered. The result of the above spacing was an average plant population of 51, 154 plants/ha with the highest in Elabered (84, 507 plants/ha) and lowest (19, 355 plants/ha) in Afabet (Table-9).

Recommended spacing varies based on cropping system, soil type and variety. In AVRDC, a total population of 26670 plants/ha is adapted (Berke *et al.*, 1999) and in Southern Australia 30, 000 plants/ha is considered good (Burt 1999). In Africa, 50, 000-80, 000

plants/ha is normal. In Mauritius, 55, 000 pl/ha gave the highest yield (6.2 t/ha), in Ethiopia 10 plants/m^3 (90, 000 plants/ha) is optimum and in Zimbabwe 30, 000-55, 000 plants/ha is adapted for chilli (Grubben and El Tahir, 2004). The results of the current study show that spacing and plant population although variable but are similar to those common in other African countries. Moreover closer spacing gives high yield in short period while wider spacing allow picking over longer period (Burt, 1999). In many of the surveyed areas the growing season is short and farmers look for faster returns which could be the reason for the tendency to the high plant population.

Table-9. Type of ridge and spacing.

	Type of ridge				**Application of specific spacing**		**Average spacing** (cm)				**Average number of plants/ha**	
Sub-region	**Basin** (%)	**NR** (%)	**RFB** (%)	**ZNR** (%)	**Yes** (%)	**No** (%)	**Intra-row**	**StDv**	**Inter-row**	**StDv**		**N**
Elabered	0.0	100	0.0	0.0	77.8	22.2	50.00	7.79	21.30	4.16	84507	18
Geleb	25	75	0.0	0.0	75	25.0	48.33	5.37	34.20	14.43	54450	16
Mendefera	0.0	80	15	0.0	85	10	49.70	20.42	29.90	6.87	60564	20
Dbarwa	0.0	84.2	21.1	0.0	73.7	31.6	52.90	6.11	31.20	6.82	54741	19
Adi-quala	0.0	100	0.0	0.0	90.9	9.1	46.50	8.83	30.80	8.35	62841	11
Dekemhare	0.0	100	0.0	0.0	82.4	17.6	48.12	9.63	23.80	6.47	78585	17
Foro	0.0	100	0.0	0.0	57.1	42.9	50.60	4.17	29.10	13.49	61123	14
Gindae	0.0	93.8	6.3	0.0	59.4	40.6	50.30	9.03	26.70	10.63	67014	32
Afabet	25	20	10	45	20	80	77.50	26.29	60.00	27.08	19355	20
Akurdat	0.0	93	6.7	0.0	53.3	46.7	64.30	19.02	33.13	14.13	42251	15
Grand mean	**4.9**	**83.5**	**6.6**	**4.9%**	**65.9**	**34.1**	**51.40**	**13.20**	**29.60**	**12.24**	**59154**	**182**

Key: NR= Narrow ridge RFB= Raised Flat Beds ZNR= Zigzag narrow ridge

Fertilization

Availability of adequate nutrients in the soil is crucial for obtaining good yield. The results of this study show that 76.9% and 70.9 of the respondents apply organic and mineral fertilizers respectively, while 9.9% do not apply fertilizer but they annually divert floods into their fields for adding silt that is rich in organic matter. The highest percentage for application of organic fertilizer (100%) was in Geleb, Mendefera, Dbarwa and Dekemhare. Similarly the highest for mineral fertilizer was 100% recorded in Mendefera, Dbarwa and Adi-quala. Respondents in Foro and Afabet were the lowest in fertilizer application with 7.1% and 10% of organic fertilizer respectively and 0% of mineral fertilizer. The reason for these low percentages is that in Foro 92.9% of the respondents use siltation and in Afabet farmers used to be dependent on diverting floods which is not currently possible due to unavailability of diversion structures that fit the current depth of the Mogae river (Table-11 and Figure-2).

Table-10. Manure and mineral fertilizer application.

	Manure			**Mineral fertilizer**		
Sub-region	**Yes** (%)	**No** (%)	**Use of siltation** (%)	**Yes** (%)	**No** (%)	**N**
Elabered	94.4	0	5.6	66.7	33.3	18
Geleb	100	0	0	75	25	16
Mendefera	100	0	0	100	0	19
Dbarwa	100	0	0	100	0	20
Adi-quala	90.9	9.1	0	100	0	11
Dekemhare	100	0	0	88.2	11.8	17
Foro	7.1	0	92.9	0	100	14
Gindae	84.4	6.3	9.4	78.1	21.9	32
Afabet	10	85	5	0	100	20
Akurdat	73.3	26.7	0	100	0	15
Grand mean	**76.9**	**13.2**	**9.9**	**70.9**	**29.1**	**182**

The results in Table-11 show that 56.4 of the respondents use purchased organic fertilizer with the highest in Dekemhare (88.2%) and lowest in Geleb (18.8%). The result also show that 52.1% of the respondent reported that organic fertilizer is not available, with the highest 82.4% in Dekemhare and the lowest 18.8% in Geleb (excluding Foro and Afabet where only 1 and 2 respondents apply fertilizer). However, this varies from place to place depending on availability of animal resources in the area, number of users and whether the farmer uses his own animal manure or purchases it. It is evident that there is positive relationship between using their own manure and its availability.

The amount of organic fertilizer applied by the respondents ranged from 0.6 t/ha to 19.2 t/ha. Collectively 79.1 % of the respondents apply amount less than 10 t/ha of them 31.2% apply less than 2.5 t/ha with the highest in 100% in Foro and lowest in 0% in Elabered. The percent of respondents who do not know the exact amount they apply was 17.1% of which the 7.1% add organic fertilizer indirectly by allowing 200-300 goats to graze and stay on the land for about 2 to 3 months. This method is specifically applied in Demas area of the Gindae sub-region. Both the grower and goat owner are benefiting by exchange of grazing permission with fertilizer left in the ground (Table-11).

Figure-1. A farmer in dogali showing the researcher amount of silt accumulated in one season.

Table-11. Source, availability and amount of manure applied

	Source		**Availability**		**Amount** (ton)					
Sub-region	**Own** (%)	**Purchase** (%)	**Available** (%)	**Not available** (%)	**<2.5** (%)	**3.5-5** (%)	**7-10** (%)	**14-20** (%)	**Unknown** (%)	**N**
Elabered	64.7	35.3	58.8	41.2	0	64.7	11.8	0	23.5	17
Geleb	81.3	18.8	81.3	18.8	62.6	12.6	0	0	25	16
Mendefera	47.4	52.6	42.1	57.9	21.1	15.8	57.9	5.3	0	19
Dbarwa	35	65	35	65	40	20	20	15	5	20
Adi-quala	60	40	70	30	21.4	28.6	50	0	0	10
Dekemhare	11.8	88.2	17.6	82.4	11.8	35.3	35.3	11.8	5.9	17
Foro	100	0	0	100	100	0	0	0	0	1
Gindae	29.6	70.4	44.4	55.6	33.3	25.9	3.7	0	37	27
Afabet	100	0	100	0	50	0	0	0	50	2
Akurdat	18.2	81.8	45.5	54.5	63.6	9.1	0	0	27.3	11
Grand mean	**43.6**	**56.4**	**47.9**	**52.1**	**31.2**	**26.4**	**21.5**	**4.2**	**17.1**	**140**

Most of the respondents (58.57%) apply mixed animal manure, with the highest in Foro (100%) and the lowest 20% in Adi-quala (Table-12). Differences in type of manure are generally due to farmer's preference and type of animals common in the area.

The results in Table-12 show that 50.4% of the farmers in the surveyed areas apply manure during land preparation with the highest in Dekemhare (94.12%) and lowest in Foro and Afabet (0%). The rest (49.64) apply it in different stages from transplanting to cultivation and even with irrigation water. This explains why farmers in many of the surveyed areas believe that manure applied in the current season is only beneficial in the following season or year.

The results in Table-13 show that 59.1% of the respondents use urea and DAP together with the highest in Dekemhare (80%) and lowest in Foro and Afabet (0%). The Table also shows that 31.8% apply only urea with the highest in Adi-quala (54.5%) and lowest in Foro and Afabet (0%). The reason for using only these two types is they are almost the only known mineral fertilizers to farmers in Eritrea except in Akurdat where a complete foliar fertilizer is used. Average amount applied is 57±35.5 and 43.6±29.2 Kg/ha of nitrogen and phosphorus respectively, 70% of the applied nitrogen is in the form of

urea; while the rest come from DAP. The highest average amount of applied nitrogen and phosphorus was in Dbarwa (71.1±46.7 and 56.3±43.3 kg/ha), while the lowest (0%) was in Foro and Afabet. Application method of mineral fertilizers is equally shared between broadcasting and side dressing where each method is applied by 44.2% of the respondents. The highest for broadcasting (57.9%) was in Mendefera and for side dressing (66.7%) in Elabered, while the lowest for both methods was 0% in Foro and Afabet (Table-13).

Table-12. Type of manure and time of application.

	Type of manure			Time of application					
Sub-region	**CD** (%)	**SRD** (%)	**Mix** (%)	**DLP** (%)	**BP and AT** (%)	**On ridge** (%)	**DC** (%)	**WIW** (%)	**N**
Elabered	11.76	5.88	82.35	29.41	29.41	5.88	35.29	0	17
Geleb	37.50	6.25	56.25	56.25	0	37.50	6.25	0	16
Mendefera	26.32	5.26	68.42	31.58	0	47.37	21.05	0	19
Dbarwa	20	10	70	25	0	55	20	0	20
Adi-quala	70	10	20	40	0	40	10	10	10
Dekemhare	17.65	5.88	76.47	94.12	0	5.88	0	0	17
Foro	0	0	100	0	0	100	0	0	1
Gindae	7.41	55.56	37.04	85.19	7.41	3.7	3.7	0	27
Afabet	50	0	50	0	0	100	0	0	2
Akurdat	9.0	45.45	45.45	18.18	0	27.27	36.36	18.18	11
Grand mean	**22.14**	**19.29**	**58.57**	**50.36**	**5.04**	**27.34**	**15.11**	**2.16**	**140**

Key: CD= Cattle dung SRD=Small ruminants dung Mix= Mixed animal manure DLP= During land preparation BP and AT= Before plough and after transplant On ridge= Before and during transplant on ridge DC= During cultivation WIW= With irrigation water

Table-13. Type of mineral fertilizer, application method and mean amount.

	Type of fertilizer				Application method				Amount				
Sub-region	**U** (%)	**D** (%)	**U and D** (%)	**U and F** (%)	**BD** (%)	**SD** (%)	**BD and SD** (%)	**F** (%)	**TN (Kg)**	**NU** (%)	**ND** (%)	**P (Kg)**	**N**
Elabered	25	8.3	66.7	0	25	66.7	8.3	0	45.2±26.65	75	25	28.5±16.35	12
Geleb	41.7	0	58.3	0	50	33.3	16.7	0	29.4±16.65	69	31	23.0±13.54	12
Mendefera	31.6	0	68.4	0	57.9	31.6	10.5	0	56.5±22.52	69	31	44.3±29.16	19
Dbarwa	25	0	75	0	45	35	20.0	0	71.1±46.69	69	31	56.3±43.3	20
Adi-quala	54.5	0	45.5	0	36.4	63.6	0	0	61.1±32.37	72	28	43.2±30.1	11
Dekemhare	13.3	6.7	80	0	53.3	40	6.7	0	51.2±28.63	65	35	46.0±25.87	15
Foro	0	0	0	0	0	0	0	0	0	0	0	0	0
Gindae	24	24	52	0	56	40	4	0	59.7±41.68	73	27	41.0±32.21	25
Afabet	0	0	0	0	0	0	0	0	0	0	0	0	0
Akurdat	53.3	0	26.7	20	13.3	60	6.7	20	62.0±24.25	70	30	48.3±27.11	15
Grand mean	**31.8**	**6.2**	**59.7**	**2.3**	**44.2**	**44.2**	**9.3**	**2.3**	**57±35.48**	**70**	**30**	**43.6±29.22**	**129**

Key: U=Urea, D=DAP, UD=Urea and DAP, F=Foliar, UF=Urea and Foliar, BD=Broadcasting, SD=Side dressing, BD and SD=Broadcasting and Side dressing, TN=Total nitrogen, P=Phosphorus, Nu=Percent nitrogen in urea form, ND=Percent nitrogen in DAP form

The amount of fertilizer to be applied depends on soil fertility and climatic conditions, thus the recommended amounts vary from place to place. However, in Eritrea there is no recommended amount of fertilized to be applied for pepper. Grubben and El Tahir, 2004 recommendation for pepper in tropical Africa is a supply of 10-20 t/ha of organic fertilizer and 130 kg/ha of N, 80 kg/ha of P and 110 kg/ha of K; in addition to Boron at the rate of 10 kg/ha. Pepper growers in Eritrea are aware of the importance of both organic and mineral fertilizers for improving yield and quality of their crop. However, the results of this study show that the amount applied is far below that recommended by Grubben and El Tahir, 2004. The main reasons for this could be unavailability of fertilizers (Tables 12 and 18) and the high cost that described during discussions with farmers and key informants as not affordable by most small scale farmers.

Insect pests, disease and weeds

The draft policy of agriculture (MoA, 2002), predicted that the build-up of insect pests and disease will be a problem in future that necessitates setting strategies for managing it. The results of the current study show that 58.8% and 56.6% of the respondents have severe insect pest and disease problems respectively. The highest severity for insect pests and diseases was recorded in

Akurdat (100 and 93.3%, respectively), while the lowest was in Adi-quala with 27.3 and 0% respectively (Figure-3). The results also show that 74.7% of the respondents use chemical control for combating insect pests and diseases. The highest was in Adi-quala (100%) and the lowest in Afabet (40%). A negative relationship was observed between intensity of chemical control and severity of insect pests and diseases excluding Akurdat where 93.3 of the respondents depend on chemical control yet recorded the highest insect pests and diseases problems (Figure-3). The high dependency on chemical control could have negative environmental and economical consequences where globally the trend is towards the organic production which will negatively affect opportunities for accessing export markets.

The most common insect pests mentioned by farmers and experts are white fly, African ball worm, aphids, rust mites and termites in addition to birds. Purple blotch, fusarium wilt, powdery mildew, downy mildew, leaf spot, cereosspora disease and anthracnose are the most serious diseases.

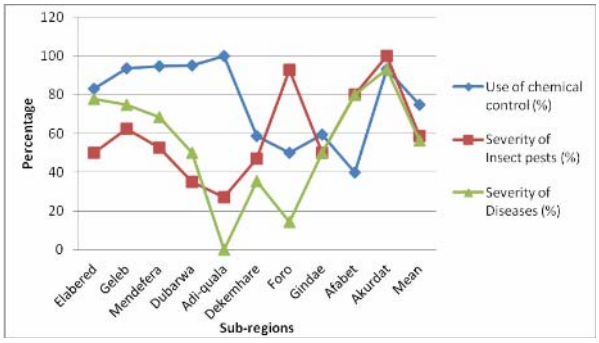

Figure-2. Effect of chemical control on severity of Insects pests and diseases in different sub-regions.

Similar to insect pests and diseases 42.3% and 39.6% of the respondents suffer severe and medium weed problems respectively. The highest for severe weed was in Akurdat (100%) and the lowest in Adi-quala (0%), while for medium the highest (73.7%) in Mendefera and the lowest (0%) in Akurdat (Table-14). Generally severity of weeds is higher in areas where flooding of fields is used like Foro, Gindae and Afabet (71.4, 59.4- and 60% respectively) or areas where most of the fields are on river banks like Akurdat (100%). Majority of the farmers (65.5%) use both cultivation and hand weeding, with highest (96.9%) in Gindae and lowest (35%) in Afabet were hand weeding using local tool is preferred (Table-14).

Table-14. Severity of weed problem and control methods.

Sub-region	No problem (%)	Low (%)	Medium (%)	Severe (%)	Cultivation (%)	Hand weeding (%)	Both methods (%)	N
Elabered	0.0	27.8	44.4	27.8	50	5.6	44.4	18
Geleb	6.3	6.3	50	37.5	62.5	0	37.5	16
Mendefera	0.0	15.8	73.7	10.5	10.5	5.3	84.2	19
Dbarwa	10.0	40	45	5.0	30	0	70	20
Adi-quala	0.0	81.8	18.2	0.0	63.6	0	36.4	11
Dekemhare	0.0	5.9	52.9	41.2	23.5	0	76.5	17
Foro	0.0	0.0	28.6	71.4	28.6	7.1	64.3	14
Gindae	0.0	9.4	31.3	59.4	0	3.1	96.9	32
Afabet	0.0	0.0	40	60	0	65	35	20
Akurdat	0.0	0.0	0.0	100	13.3	0	86.7	15
Grand mean	**1.6**	**16.5**	**39.6**	**42.3**	**24.2**	**9.3**	**66.5**	**182**

Yield

The results of the current study show that average yield for green pepper was 3.4±2.7 t/ha. The highest mean yield was in Dbarwa (6.1±3.4t/ha) followed by Mendefera (4.8±4t/ha) and the lowest mean yield was in Afabet (1t/ha). The highest maximum yield was recorded in Mendefera (18t/ha) and the lowest in Afabet (1t/ha) while the highest minimum yield was 3t/ha recorded in Dbarwa and the lowest 0.3t/ha recorded in Akurdat. For dry pepper average yield was 0.87±0.8t/ha with the highest mean yield of 1.6±1.04t/ha in Dbarwa and lowest mean yield of 0.35±0.36t/ha in Mendefra. The highest maximum yield was 4t/ha recorded in Akurdat and the lowest 1t/ha recorded in Elabered, Mendefera, Adi-quala and Dekemhare, while the highest minimum was 0.7t/ha recorded in Akurdat and the lowest 0.02t/ha obtained in Gindae (Table-15). This very low minimum yield of dry pepper in Gindae was recorded in an area of rainfed

pepper production that has been experiencing drought conditions for the last few years in addition to that farmers tend to harvest the early fruits as green crop before allowing it to fully mature and harvested dry. Average yields found in this study are very low compared to the 2011 world and African averages which (FAOSTAT, 2012). However, it reflects the reality that productivity of pepper in Eritrea is greatly declining. For green pepper; Eritrea that used to have an average yield of 8.12t/ha in 1968 (Table-16) which is greater than the average of Africa in 2011(FAOSAT 2012), is today among the lowest in yield per hectare. In the last few years yield of green pepper declined from 10.6 t/ha in 2008 to 7.3 t/ha in 2010 to 3.7 t/ha in 2011 (Table-16).

Table-15. Yield per hectare for green and dry pepper.

	Green pepper (ton/ha)			**Dry pepper** (ton/ha)		
Sub-region	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Elabered	2.9±2.20	7.5	0.5	0.51±0.38	1.0	0.10
Geleb	2.5±1.21	4.8	1.0	0.55±0.67	1.6	0.10
Mendefera	4.8±4	18	1.0	0.35±0.36	1.0	0.03
Dubarwa	6.1±3.42	12	3.0	1.60±1.04	3.0	0.15
Adi-quala	2.9±1.56	6	1.0	0.54±0.36	1.0	0.15
Dekemhare	2.7±1.32	6	1.0	0.61±0.36	1.0	0.10
Foro	2.5±0.97	4	1.2	0.97±0.84	3.0	0.30
Gindae	2.4±1.65	8	0.4	1.17±1.15	3.0	0.02
Afabet	1.0±0	1	1.0	0.60±0.32	1.3	0.20
Akurdat	2.4±1.58	5	0.3	1.38±0.92	4.0	0.70
Grand mean	**3.4±2.72**	**18**	**0.3**	**0.87±0.81**	**4.0**	**0.02**

Table-16. Development of green pepper in Eritrea.

Year	**Area** (ha)	**Production** (ton)	**Yield** (ton/ha)
1957[1]	136.4	99	7.25
1958[1]	117.4	70	5.9
1959[1]	117.4	84	7.2
1960[1]	161.5	84	5.2
1968[1]	1045	8482	8.12
2010[2]	2,874	21,010	7.3
2011[2]	4,132	15,118	3.7

Constraints and opportunities of pepper production in Eritrea

Up to 1974 Eritrean average annual export of horticultural crops was US$1.02 million (Bank of Ethiopia, 1965-1974). During this period pepper production and export in Eritrea was increasing and mean yield per ha as per 1968 (8.2 ton/ha) was much greater than the 2011 average of 3.7 ton/ha (Table-17). It was also greater than average yield/ha of Africa for 2011 which is 7.47 (FAOSTAT, 2012). In 2011 area cultivated with pepper in Eritrea was 4 times greater compared to the cultivated area in 1968, however due to the decrease of yield/ha by half, the production in 2011 is only double of that of 1968. This indicates to several constraints contributing to the current low production and productivity of pepper in Eritrea as well as its quality. Constraints identified by the Eritrean national agricultural development strategy and policy (MoA, 2006) are; small land size and discouraging tenure system, declining soil fertility, seed, weeds, insect pests and diseases, labour, lack of skill based extension support, insufficient access to water, in adequate supply of inputs and services and high post-harvest loss. The results of the current study are similar to that. Table-17 summarizes the results extracted from contacting 25 experts, conducting 9 farmer group discussions and interviewing 182 individual farmers.

The results show for more than 88% of the respondents; inputs were considered unavailable (Table-18) resulting in escalating prices and reduced quality of some commodities. Similarly discussions with farmers and key informants revealed that other inputs such as small tools and fuel and services like maintenance service, tractor and machinery services are not available. Previously the Ministry of Agriculture was the major supplier of inputs and service; during the last few years unknown sources are dominating. Machinery services and fuel are currently provided by the Government Garages, they are not adequate and available on time.

Improved varieties and quality seed is the basis for any improvement in production and quality. The discussion showed that pepper is the only crop of the major vegetables that had no attention from the ministry to provide farmers with improved and good quality seed (Table-19). The National Agricultural Research Institute released 5 lines (NARI, 2005-2011); however, due to absence of seed production system only an average of 17 kg of seed is annually distributed by the institute.

Consequently farmers are using their own seed or purchase unknown quality seed from the dry consumption market instead of the improved seed.

Table-17. Number of groups, key informants and individual farmers considered the listed values as major constraint in pepper production.

	Constraints	Group discussion	N	Key informants	N	Individual farmers	N
1	Inputs and services	8	9	19	25	148	182
2	Improved and quality seed	7	9	18	25	94	182
3	Pests and diseases	9	9	12	25	56	182
4	Water scarcity	5	9	9	25	34	182
5	Land tenure and holding size	5	9	9	25	33	182
6	Extension service	5	9	8	25	25	182
7	Labour	3	9	11	25		182
8	Marketing ch	3	9	2	25	13	182

Table-18. Percentages for availability of mineral fertilizer, fungicide and insecticide.

	Mineral fertilizer (%)		**Fungicide** (%)		**Insecticide** (%)	
Sub-region	**Available**	**Not available**	**Available**	**Not available**	**Available**	**Not available**
Elabered	0.0%	100.0%	7.7%	92.3%	15.4%	84.6%
Geleb	27.3%	72.7%	15.4%	84.6%	15.4%	84.6%
Mendefera	5.3%	94.7%	5.3%	94.7%	5.3%	94.7%
Dubarwa	15.0%	85.0%	15.8%	84.2%	25.0%	75.0%
Adi-quala	9.1%	90.9%	33.3%	66.7%	0.0%	100.0%
Dekemhare	0.0%	100.0%	0.0%	100.0%	9.1%	90.9%
Foro	0.0%	0.0%	33.3%	66.7%	42.9%	57.1%
Gindae	20.0%	80.0%	15.8%	84.2%	10.5%	89.5%
Afabet	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Akurdat	13.3%	86.7%	0.0%	100.0%	0.0%	100.0%
Grand mean	**11.7** %	**88.3** %	**11.2** %	**88.8** %	**11.9** %	**88.1** %

Results of the survey show that the insect pests and diseases problem is of a major concern of farmers as well as experts (Table-19). Total crop failure due to termites in Foro and unknown disease in Dekemhare has been reported. Inefficiency of chemicals available due to unknown source and expiry and being used for long time that may result in pests develop resistance to it are part of the problem mentioned.

The results of the discussions show the main issues of land as a constraint are the tenure system and size of land (Table-17). The three land tenure systems of Eritrea Diesa, Risti and Dominale. The latter two systems has no problem in maintaining the quality of soil, however, the Deisa system in which all lands are communal property of the village and redistributed equally to all members of the village every 5-7 may have some disadvantages regarding the land-improvement point of view. The farmers have no incentive to long-term investment on land. Land is exposed to wind erosion due to open to communal grazing out of season and cannot be used as security to obtain credit (Negassi *et al*., 2000). The discussion also revealed that small land size in the Diesa and Resti systems push producers to use rented land in the absence of regulating law between the land owner and renter which interfere with proper investment on land.

Water was discussed as one of the major problems that cause partial or sometimes total crop loss in some areas. Generally in Eritrea rainfall is low and significantly varies from year to year (Hurni and Koller, 2002). Average annual rainfall is about 380 mm, varying from less than 50 mm to over 1 000 mm. Over 90 percent of the total area receives less than 450 mm and only 1 percent receives more than 650 mm of annual rainfall (Frenken, 2005). The results in Table-19 show that 81.9% of respondents grow irrigated pepper. It shows also that 90.8% of the respondents use underground water from

boreholes. Ground water is the basis for domestic water supply. It can be tapped in all parts of the country but not in the quantities and qualities desired (Frenken, 2005). Streams are few and all the other water sources available for the growers depend on the amount of rainfall and length of the rainy season for recharging them (Table-19). Therefore, farmers complained of the increased depth of wells and reduced water in the rivers due to reduced rainfall water. Based on water availability the irrigation potential can be estimated at 187 500 ha (Frenken, 2005). The current irrigated land is only 28, 000 ha (MoA, 2012). The results of the current study show that all the respondents use surface irrigation that consume large amount of water (data not shown), especially under the climatic condition of Eritrea where annual evapotranspiration rates range from 1900 mm to 8000 mm (Frenken, 2005). Thus, at country level water shortage may not be currently the problem but efficiency of irrigation methods.

Table-19. Type of crop and source of water.

	Type of crop			Source of water			
Sub-region	**Irrigated** (%)	**Rain-fed** (%)	**Supplementary irrigation** (%)	**Borehole** (%)	**River/stream** (%)	**Dam** (%)	**N**
Elabered	55.6	11.1	33.3	87.5	12.5	0.0	18
Geleb	100	0.0	0.0	100	0.0	0.0	16
Mendefera	73.7	0.0	26.3	100	0.0	0.0	19
Dubarwa	65	0.0	35	90	0.0	10	20
Adi-quala	90.9	0.0	9.1	100	0.0	0.0	11
Dekemhare	100	0.0	0.0	100	0.0	0.0	17
Foro	100	0.0	0.0	77.8	22.2	0.0	14
Gindae	62.5	37.5	0.0	95.2	0.0	4.8	32
Afabet	100	0.0	0.0	65	35	0.0	20
Akurdat	100	0.0	0.0	100	0.0	0.0	15
Grand mean	**81.9**	**7.7**	**10.4**	**90.8**	**7.5**	**1.7**	**182**

Farmers need technical support for improving their production technologies and skills. The results of the current study show there are no adequate extension services. The ratio of extension agents to farmers in 2001 was 1:2, 800, which is below the average for all developing countries (MoA, 2002). Currently the number may not be a problem, but the function and skill. Too many function of extension agents and low level of education and training of extension agents combined with low level of farmer education are some of the major problems identified during field visits of a strategy team in Eritrea (Steele, 2002). The current number of agents is not very low; however, they are production oriented and service providers and not farmer support agents (MoA, 2006).

The primary source of labour for small scale production in Eritrea is family labour; while commercial producers depend on hired labour. However the results show that only 18% of the respondents use family labour, 46% depends on both hired and family labour and 17% on hired labour; while the rest 20% exchange labour for half of the yield. This indicates to lower input of family labour (data not shown). Leading to small scale farmers competing for hired labour with commercial farmers, as a result labour is unavailable and expensive. Seasonal labour no longer arrives from Northern Ethiopia, and a very large proportion of Eritrea's economically active men are in military service (MoA, 2006).

Eritrea has a rich experience in the marketing of horticultural products locally and for export. However, it has been drastically eroded over the years. There is a need for building up an efficient marketing system (MoA, 2006). Discussions with farmers and extension workers show that middlemen are the most beneficiaries of the products under the current marketing system where farmers carry their harvest, pay for transportation up to the whole sale shop and accept the offered price. In rare cases under scarcity conditions middlemen may collect the produce at the farm. Currently post-harvest losses not a problem for pepper farmers, they usually market their product the same day or the next day so less causes of spoilage. Dry pepper may be stored for some period with no spoilage problem if well dried.

Favourable climate, availability of land, market, experience and willingness to grow pepper are the major opportunities identified through the discussions and secondary data.

Although a small country; Eritrea enjoys 6 agro-climatic zones that allow growing variety of species and crop varieties. Most of the regions are suitable for growing pepper at least in one growing season. Exception to that is the southern part of the coastal plains zone where limited

agricultural land exist and high temperatures that may not be suitable for commercial pepper production.

Although the results show dominance of small acreage (Table-5), the secondary data show availability of land in all the surveyed areas (Table-20). Total potential irrigable land of Eritrea is 600, 000 ha (MoA, 2012). Based on water availability the irrigation potential can be estimated at 187 500 ha. (Frenken, 2005). The current area under irrigated cultivation is only 28, 000 ha. Thus there is an opportunity for pepper to compete in these lands.

Table-20. Irrigated land under cultivation and potential irrigable land in the four.

Region	**Potential area** (ha)	**Developed area** (ha)	
		Area (ha)	%
Gashbarka	93465	11880	12.7
Anseba	66352	1604.15	2.4
S/K/Bahri	4220	1663	74.95
Debub	17043	3732.5	21.9
Total	**181, 080**	**18, 879.7**	**10**

Eritrea is still depending mainly on imported dry pepper. According to the Customs Department the value of the imported pepper in 2010 was around US$ 8 million, this is apart from the illegal importations. So the local market can still absorb huge quantities if good quality pepper produced. Pepper was identified as one of the crops that potentially have comparative advantage in export markets (MoA, 2006), therefore the closeness of the country to export markets can be an additional potential if export requirements satisfied.

Pepper has been grown for a very long time so many farmers accumulated considerable amount of experiences in growing pepper (Table-4). These experiences can be exploited in improving production technologies.

Profit is a major motive for farmers to continue growing any crop. The results of this study show that 76.6% and 82.4% of the respondents think that both green and dry pepper respectively are profitable and 91% are willing to continue growing it even if it is not profitable. The reason for that is Eritrean farmers grow pepper not only for market but also for home consumption and many consider it way of life. Thus, pepper will continue as one of the important crops of Eritrea which necessitates mechanisms for improving it.

CONCLUSIONS AND RECOMMENDATIONS

Availability of vast lands, favourable climate, domestic and export markets and experienced farmers with high willingness to grow pepper are of the major opportunities for pepper production in Eritrea. Constraints are, unavailability of improved and quality seed, inputs and services, insect pests and diseases, small acreage, discouraging land tenure system, improper marketing chain, poor extension service and persistent drought that affect availability of water.

Pepper in Eritrea has great potential, however, constraints need to be overcome and opportunities maximized. Improving the existing pepper genotypes could have significant contribution in solving some of the major problems in pepper production, such as the productivity, quality, and resistance to major pests or diseases, drought tolerance. Therefore the following recommendations are suggested:

- A well designed breeding program that focuses on the existing local pepper genotypes that has been in cultivation for long time should be initiated.
- Provision of agricultural inputs and services should be considered.
- Agricultural extension service should provide farmers with technical support to improve their practices regarding maintaining or obtaining good quality seed, nursery practices, irrigation methods, insect pest and disease control.
- The land tenure system problem although complicated, actions can be taken to solve some problems. For example policies and regulation should be put in place to organize the relationship between owners and renters.
- Farmers' association initiatives should be strengthened in order to help solve marketing problems and production related issues.

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REFERENCES

Amanuel Negassi, Bo Tengnäs, Estifanos Bein and Kifle Gebru. 2000. Soil Conservation in Eritrea, Some case studies. Technical Report No. 23. Regional Land Management Unit, Sida.

Bank of Ethiopia. 1962. Annual report. Bank of Ethiopia, Eritrea Branch.

Berke T.G., Black L.L, Green S.K., Morris R.A., Talekar N.S. and Wang J.F. 1999. Suggested Cultural Practices for Chili Pepper. International Cooperators guide, AVRDC, Taiwan.

Berke T.G. 2000. Multiplying Seed of Pepper Lines. International Cooperators guide, AVRDC, Taiwan.

Burt Jhon. 1999. Growing capsicums and chillies, Farmnote 64/99. Chief Executive Officer, Agriculture Western Australia.

Cathy Green with Sally Baden. 1994. Gender profile of the state of Eritrea. Report No. 22, BRIDGE (development - gender) Institute of Development Studies, University of Sussex Brighton BN1 9RE, UK.

Djian-Caporalino *et al*. 2006. cited in Sheh May Tam *et al*. 2009. Theoretical and Applied Genetics. 119(6): 973-989.

FAOSTAT | © FAO Statistics Division 2012 | 31 May 2012 available online from www.faostat.fao.org.

Grubben G.J.H. and El Tahir Ibrahim Mohamed. 2004. *Capsicum annuum* L. In: Grubben, G.J.H. and Denton, O.A. (Editors). PROTA 2: Vegetables/Légumes. [CD-Rom]. PROTA, Wageningen, Netherlands.

Hurni and Koller. 2002. Cited by Beraki A. F. 2005, Climate change scenario simulations over Eritrea by using a fine resolution limited area climate model : temperature and moisture sensitivity, M.Sc dissertation, University of Pretoria, Pretoria, Accessed on 18/02/2013 < http://upetd.up.ac.za/thesis/available/etd-02102006-152327 / >.

Karen Frenken. 2005. Irrigation in Africa in Figures AQUASTAT Survey. FAO Water reports 29. FAO Land and Water Development Division. pp. 2011-2018.

Kelley W. Terry and Boyhan George. 2006. Commercial pepper production handbook, cultural practices and varieties. The University of Georgia, Cooperative Extension.

Mariyono J. *et al*. 2009. Factors affecting adoption of chilli crop in Central Java. Kumpulan Maklah Seminar Perhorti.

Ministry of Agriculture. 1996. Eritrea: Country Report to the FAO International Technical Conference on Plant Genetic Resources. Leipzig, Germany.

Ministry of Agriculture (MoA). 2002. Agricultural Sector Policy and Strategy Framework. The State of Eritrea, Ministry of Agriculture.

Ministry of Agriculture. 2006. Eritrean National Agricultural Development Strategy and Policy. Chapter 11. Crop and Horticulture Development Strategy (Draft). The State of Eritrea, Ministry of Agriculture.

Ministry of Agriculture. 2011. Annual statistical report, Planning and Statistics Division Office, Ministry of Agriculture, Eritrea.

Ministry of Agriculture. 2012. Planning and Statistics Division Office, Ministry of Agriculture, Eritrea.

Ministry of Agriculture. 1957-1968. Annual reports. Ministry of Agriculture of Ethiopia, Eritrea Branch, Asmara.

Rashid M. A. and Singh D. P. 2000. A Manual on Vegetable Seed Production in Bangladesh AVRDC-USAID-Bangladesh Project-Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur 701, Bangladesh.

Roger E Steele. 2002. Strengthening Human Capacities for Implementing a New Demand-Driven Extension Approach in Eritrea. Proceedings of the 18th Annual Conference Durban, South Africa AIAEE.

UNESCO 2912. High level International Round Table on Literacy. Reaching the 2015 Literacy Target: Delivering on the promise. Action Plan Paris, 6-7 September.

United Nations. 2004. State of Eritrea, Public Administration Country Profile. Department of Economic and Social Affairs (DESA), Division for Public Administration and Development Management (DPADM).

ANNEX

Table-A. Key informants interviewed in different offices.

Place	Number of interviewed experts
MoA headquarters	3
National Agricultural Research Institute	3
Southern region	10
Anseba region	2
Northern Red Sea region	5
Deseret Locust Control Organization*	1
Eritrean Sugar Corporation*	1
Total	**25**

* Pathologist and entomologist served in MoA for very long time and recently moved to other organizations.

Table-B. List of the visited offices and documents or data collected.

S. N.	Office visited	Documents or information collected
1	Planning and Statistics Division, MoA headquarters	The following documents have been collected agricultural achievements 1992-2009 production data for the last 10 years agricultural policy and strategy constraints and issues in crop and horticulture development
	Agricultural Extension Department,	Horticulture survey document (conducted 2008)
2	Department of Customs	Report of export data
3	National Statistics Office	Data of pepper consumption
4	Department of Foreign trade, Ministry of Trade and Industry	Documents related to export of agricultural commodities
5	National Agricultural Research Institute	Consultancy report on horticulture research 2004-2005 Consultancy report on horticulture research 2005-2007 Annual reports 2005-2011 5 seed samples to be utilized in the morphological and molecular characterization experiments
6	MoA, Debub regional office	Annual reports 2005-2011 List of horticulture farmers in the zoba Rainfall data 2000-2011
7	MoA, Northern Red Sea regional office	List of horticulture farmers in different sub-zobas
8	MoA, Anseba regional office	Annual reports