Mapping the Current Knowledge of Carrot Cultivation in Ethiopia

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Submitted to

Carrot Aid

Denmark

August 2012

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Acronyms

AISCO	Agricultural Inputs Supply Corporation
ARARI	Amhara Regional Agricultural Research Institute
CIDA	Canadian International Development Agency
CSA	Central Statistics Authority
DAP	Di-ammonium Phosphate
DAs	Development Agents
DBARC	Debre Brehan Agricultural Research Center
DM	Dry matter
EARO	Ethiopian Agricultural Research Organization
ERCA	Ethiopian Revenue and Customs Authority
GCT	General Chemicals Trading
EIAR	Ethiopian Institute of Agricultural Research
IAR	Institute of Agricultural Research
MoA	Ministry of Agriculture
PRA	Participatory Research Appraisal
SNNPR	Southern Nations Nationalities and Peoples Region
WHO	World Health Organization
WOoA	Woreda Office of Agriculture

Acknowledgements

The authors acknowledge experts and Development Agents (DAs) of woreda offices of agriculture in the study area. Our acknowledgement is also extended to staff of horticulture team at Debre Brehan Agricultural Research Center (DBARC) for their collaboration. The libraries of Ethiopian Institute of Agricultural Research (Addis Ababa) and DBARC are also acknowledged for availing literature under their holdings.

Introduction

Vitamin A malnutrition is one of the major public health problems that is being investigated in Ethiopia since 1958. Postmus (1958) reported that 9% of girls and 2.2% of boys out of seven thousand preschool and school-aged children had Bitot's spots, a disease symptom due to vitamin A deficiency. The Ethiopian Nutrition Institute also revealed that overall national rate of Bitot's spots was 1%, i.e. about six to eight million Ethiopian children under six years of age were at risk of vitamin A deficiency (Wolde-Gabriel, 1985). The prevalence was 1.6% in pastoral, 1.1% in grain crops based and 0.4% in cash crop based areas. De Sole (1987) also reported a 5% prevalence of Bitot's spots among children in southern Ethiopia. Micronutrient baseline surveys conducted by World Vision Ethiopia in ten rural districts of Ethiopia further showed that 6.4% of the 1246 children aged 6 to 71 months and 7.5% of the 3003 children aged between 6 and 14 years had Bitot's spots (Balcha, 2011). The prevalence is 2- to 15-folds greater than the World Health Organization (WHO) cut-off point (0.5%) for public health significance. Hence, micronutrient malnutrition, vitamin A deficiency in particular, continues to be one of the major public health problems in Ethiopia.

Efforts have been made to mitigate nutrient malnutrition by different non-governmental organizations. The World Vision Ethiopia Micronutrient Program, with a 6.75 million USD budget from the Canadian International Development Agency (CIDA) supported about two million beneficiaries (especially mothers and children) in four major regions of the country between 1997 and 2001. Production and consumption of vegetables and fruits was one of the strategies used in the program (Balcha, 2001). Similar efforts were made by the Shebe Health Project of Finnida from the government of Finland. Carrots have been one of the most important means used to mitigate vitamin A deficiency.

Carrot roots are a rich source of carotenoids, precursors of vitamin A. The carotenoids contained in the edible portion of carrots can range from 6000 to more than 54,000 μg per 100 g, (60–540 ppm) (Simon and Wolff, 1987). Carrots are the single most important source of dietary pro-vitamin A carotenoids in the USA, accounting for 30% of the total vitamin A available to consumers (Simon, 1992). Thus carrots have acquired worldwide acceptance due to their high vitamin A content, acceptable taste, ease of production, and relatively long storage life at low temperature. They are well adapted to mid and high altitude areas, both under irrigation and rain fed conditions in many parts of Ethiopia (IAR, 1979). They are mainly consumed in urban areas of the country which is about 15% of the population. However, their value as an important source of vitamin A is not well exploited in the country due to lack of awareness among the majority of the Ethiopian rural population. Although the exact time of introduction of carrots to Ethiopia is not well known, carrots have been known since the early 1960s in the research system and to the community following the establishment of agricultural

schools and experimental stations. Later nationwide efforts to test and adopt agricultural technologies across different agro-ecologies contributed to the popularization of carrots among other vegetables. However, carrots, like any other imported vegetable, are cultivated mainly in the pre-urban and some rural areas that target urban markets. The rural community does not produce carrots regularly or buy from markets to supplement/fulfil its nutrition requirements. Despite the nutritional value and importance as sources of income to different communities, carrots have received little attention in research, extension and development. The fragmented works done so far are found scattered in different institutions across the country and have not been compiled into a usable document. The overall objective of the present study is therefore to map past and present knowledge of carrot production in Ethiopia and thereby to avail information to stakeholders who will persue further research and development activities on carrots. The specific objectives of the study were:

i) to assess the existing carrot production and marketing systems in major production areas
ii) to review and document past research and development activities in carrots and
iii) to design intervention options for the empowerment of carrot growers

Methodology

The study was conducted in the major carrot growing areas of the country mainly in the central highlands of Arsi, North Shewa, Addis Ababa, and Southern Nations and Nationalities and Peoples' Region (SNNPR). Both primary and secondary data were used. Participatory approach was applied in generating the required primary information along with prioritization of existing constraints and opportunities for carrot production and marketing. Participatory Rural Appraisal (PRA) techniques through focused group discussions, key informants and document reviews were the major sources of information needed for the analysis. Secondary data needed for characterization of the production trends, supply, and prices were collected from relevant sources/publications.

Experience in Carrot Root Production

Carrot production and trends in Ethiopia

Currently, about 12345.8 t of carrot is produced in Ethiopia on 2215 ha of land (CSA, 2010/11). Although the production trend is not consistent from year to year, the production of carrots has doubled between 2004/5 and 2010/11 (Table 1) mainly due to increasing urbanization and the recognition of carrots as an income and nutrition source. Farmers in Hararghe area also generate foreign currency from exporting carrots to neighbouring Djibouti and Somalia. Moreover, foreign currency income obtained from exporting fresh or chilled carrots and turnips increased from a mere 581 USD in 1997 to 517,172 USD in 2011 (Table 2). In addition, a

significant number of individuals get their income from brokering, trading (wholesale or retail), and transporting carrots.

Carrots are produced in a wide range of agro-ecologies from the lowlands to the highlands of Ethiopia. They are frost tolerant and have become one of a few alternative crops that can be grown in the frost prone highlands around 3000 masl. They grow in well drained alluvial and sandy loam soils but not in heavy clay and water-logged soils. Carrots are usually grown on small plots in the backyards of town and peri-urban dwellers for family consumption; however, some farmers grow carrots on up to 0.25 to 1 ha as a means of income. Carrots can be grown throughout the year if rain and irrigation water is available (Table 3). In highlands that get bimodal rainfall, two cycles of carrots can be produced based solely on rain. These are the short rainy season (*Belg*, March to May) and the long rainy season (*Meher*, June to September). The third cycle is also possible between October and March with irrigation water.

Table 1. Carrot production in Ethiopia from 2004/5 to 2010/11

Year	No of holders	Area (ha)	Production (t)	Productivity (t/ha)
2010/11	117649	2214.9	12345.8	5.6
2009/10	157032	2712.7	18229.3	6.7
2008/9	205637	2100*	13466.6	6.4*
2007/8	149484	1400*	10000*	7.1*
2006/7	137052	946.7	6694.1	7.1
2005/6	134358	1071.2	6881.5	6.4
2004/5	138208	1741.0	17.9	10.3

Source: CSA, 2004/5 to 2010/11

*Source: faostat.fao.org

Table 2. Export of fresh or chilled carrots and turnips from Ethiopia*

Year	Destination	Net weight (tones)	Value (USD)
1997	Djibouti	0.34	581.51
1999	Djibouti	1.76	398.91
2000	Djibouti	0.10	14.80
2001	Djibouti, Somalia, USA	404.19	72,890.27
2002	Djibouti, Sudan	414.77	66,403.84
2003	Djibouti, Sudan	427.96	72,474.71
2004	Djibouti, Svalbard & Jan Mayen Islands , USA	399.13	61,013.67
2005	Djibouti, Jamaica	372.70	55,547.17
2006	Djibouti	500.05	75,445.23
2007	Djibouti	640.62	96,635.21
2008	Djibouti	587.57	87,965.55
2009	Djibouti	798.54	120,023.40
2010	Somalia, Djibouti,	1675.65	316,912.00
2011	Somalia, Djibouti,	2753.52	517,172.70
Total		8980.39	1,543,479.00

* It is not possible to separate data for carrots and turnips
Source: www.erca.gov.et

Table 3. Major carrot production areas and seasons in Ethiopia

Region Zone/Woreda	Major production areas (Kebeles)	Altitude range (masl)	Seasons*	Planting time	Harvesting time
Oromiya					
Arsi Zone /Shirka woreda	Alef Waji, Alaf Tijo Sero, Tijo Lebu Sole Digalof Guna, Lemuf Tijo (Gebre Kirstos)	1800-300	*Meher* *Belg*	July March	Sept. June
			Irrigated	Oct.	Jan.
Arsi Zone /Bokoji	Lemu Mirt, Enkolo Farechu, Hulule Lemu Dima, Lemu Burkitu	2500-2800	Meher	July	Oct.
			Belg	March	June
			Irrigated	Sept.	Dec. -Feb.
Arsi Zone /Enkolo-Wabe	Lemu Kara, Teji Welkite, Lemu Leman	>3000	*Meher*	May/June Sept.	Sept. Jan./Feb.
			Belg	Mar./Apr.	July
East Haraghe /Haramaya Kombolcha	Haramaya, Kombolcha	1900-2000	*Meher*	June	Sept.
			Irrigated	Oct. -March	Jan. - June
Amhara					
	North Shewa (Menz mama) Debre Brehan (Borale, Meqa)	2200-2700	*Meher*	June	Sept.-Oct.
			Belg	Feb. -March	May - June
			Irrigated	Sept. –Nov.	Dec. -Mar
Addis Ababa					
	Akaki Kaliti, Gulele, Nifas Silk, Kolfe Keraniyo	2000-2200	*Meher*	June	Sept./Oct.
			Irrigated	Oct. –Mar.	Jan.-June
Tigray					
East Tigray /Ganta Afeshum	Dibla, Sasun, Simret	nd**	*Meher*	mid Aug.	mid Dec.
			Irrigated	1st week Oct.	mid Jan
South East Tigray/ Enderta	Arato, Cheelekot, Didiba	nd	Irrigated	1st week Dec.	mid March
South Tigray /Enda Mekoni	Embahazti, Simret, Shimta	2500-2800	*Meher*	3rd week June	end Sept.
			Irrigated	1st week Dec.	mid March
SNNPR					
	Hadiya (Lemu, Hosena Zuria) Wolayta (Sodo Zuriya, Kokate, Murachire), Bench Maji, Gurage Sidama (Wendo Genet), and Gedeo zones	1800-2000	*Belg*	April	Aug. /Sept.
			Meher	Aug.	Dec./ Jan.

**Meher* is the long (main) rainy season from June to August; *Belg* is short rainy season from February/March to April
**nd no data

Seed supply

Seeds are supplied by government parastatal companies such as the Ethiopian Fruit and Vegetable Marketing Enterprise (Etfruit) and Agricultural Inputs Supply Corporation (AISCO). Etfruit supplies the Nantes variety from Dutch companies and distributes from its store in Addis Ababa to its branches in regional towns, seed retailers and farmers in different parts of the country. AISCO used to import seeds in bulk and distribute to Woreda Office of Agriculture (WOoA); however, the seeds were introduced in excess of demand due to exaggerated requests from woredas. Consequently, the seeds expired after many years of storage. Currently, it requires a prior confirmation from WOoA to supply seeds. The seed quality from government sources is reported to be of high germination and true-to-type. Private companies such as Chemtex and General Chemicals Trading (GCT) also used to import good quality seeds, however, due to unfair competition from companies which import poor quality seeds at lower prices, they ceased to import vegetable seeds (Girma, personal communication). Farmers and extension agents in different parts of the country often report that seeds from private companies are often of poor quality (poor germination and not true-to-type to the variety). Both government and private companies import seeds from Dutch companies such as Proseed, Backer Brathors and Top Harvest.

Variety adaptation trials

Carrots were a popular crop in Hararghe, eastern Ethiopia. Farmers were producing and saving their own seeds of carrot. However, roots from the local seeds lacked uniformity and quality. As a result, seeds of eight varieties were imported from Kenya and a variety trial was initiated at the College of Agriculture at the then Alemaya College of Agriculture (now Haramaya University) in early 1960s (Table 4). Among the eight varieties tested Nantes and Chantenay gave good root yields. Nantes had the best quality roots and became very popular in Haraghe. Chantenay was also well accepted (Kidane-Mariam, 1969). Simret (1994) reported that from adaptation trials undertaken at various agro-ecological zones between 1983 and 1988, Nantes and Chantenay gave a root yield of 19.6 and 21.7 t/ha in the highlands (2201 to 3000 masl), 23.2 and 24.1 t/ha in the mid-altitudes (1701 to 2200 masl), and 21.2 and 19.7 t/ha in the lowlands (500 to 1700 masl), respectively. The result indicted that both varieties were suited to mid-altitude areas while Chantenay was more suited to high altitudes than lowlands and the vice-versa was true for Nantes. Nantes grown at Melkassa (1600 masl) at the spacing of 20 cm between rows and plants matured in 86 days and gave 13.7 t/ha marketable yield due to low stand density (66%). About 10% of the roots were unmarketable.

As the result of variety adaptation trials, Nantes and Chantenay were recommended to be grown in various parts of Ethiopia. The characteristics of the two varieties are:

1. Nantes has orange colored and cylindrical roots with a blunt end and strong leaves. It is in high demand among farmers for its good adaptation in highlands and high market demand for its good color, thick and long roots and sweet taste.

2. Chantnay has shorter roots than Nantes, deep orange color and a sharp tip. It has a long shelf life and is suitable for long distance transport.

Table 4. Yield (t/ha) of eight carrot varieties in variety trial at Alemaya, 1960-61

Variety	Year		Average
	1960	1961	
Royal Chantenay	35.5	32.3	33.9
Imperator	28.5	26.9	27.7
Ox-heart	26.1	20.7	23.4
Nantes	33.2	35.5	34.3
Amsterdam Forcing	-	20.7	20.7
Chantenay	32.9	29.7	31.3
Nantes Improved Red	36.6	34.8	35.7
Touchone	-	29.1	29.1

Source: Kidane-Mariam (1969)

Adaptation trial conducted at Hawassa in 1978/79 on a plot size of 31.4m^2 and spacing of 20 cm between rows and 10 cm between plants showed that Palisade variety gave 10.1 t/ha of marketable yield (IAR, 1986). The variety had ~4% unmarketable roots due to cracking. In 1979, var. Manchester Table was tested for adaptation at Holleta on 24m^2 at a spacing of 25 cm and 10 cm between rows and plants. The variety matured in 140 days and gave 3.0 t/ha of root yield. It had a high unmarketable yield of 34% due mainly to non-typical color and small-sized roots. Trials conducted at Melkassa suffered from poor establishment due to improper distribution of rain and terminal low moisture stress during the *Meher* growing season resulting in small-sized roots and a low yield.

Recently, two varieties of carrot (Samson and Strong King) were introduced from The Netherlands and Denmark, respectively. The first variety is open pollinated while the latter one is hybrid. Both varieties were verified under multi-location adaptation trial and registered/recommended for production during the 2011 crop season. Both varieties were high yielders with good quality of roots (MoA, 2011).

Agronomic practices

Seed bed preparation:- Carrots need finely prepared soil to suit the germination of their small seeds. Thus farmers plough and prepare land for carrots five to six times before planting. Those in Arsi highlands prepare raised beds. Ridge and furrow beds are used for irrigated carrot during

the dry season for easier irrigation. Flat or raised beds are used for rain fed production. Flat beds are used where there is good drainage but raised beds are used in poorly drained soils during the *Mehe*r season. Bed size varies from place to place and often ranges from about 0.8m to 1m in width and 10 m to 12 m in length. Nonetheless, some farmers use flat beds and flood irrigation in the dry/irrigated season.

Seed sowing:- Seed rate of carrots ranges from 4 to 5 kg/ha in most parts of the country. Growers in North Shewa, SNNPR and Tigray broadcast carrot seeds on the seedbed. Those in the Arsi highlands plant in rows across the seedbed. The rows are 20-25 cm apart. The spacing between plants is not constant and varies from 5 to 10 cm due to difficulties to uniformly drill the small carrot seeds. Farmers in Arsi highlands use plastic bottles with a narrow hole at its bottom to uniformly drill the seeds.

A trial was conducted to evaluate the optimum sowing date for root production at Holeta (2400 masl, (IAR, 1986). The seeds were sown at an interval of 15 days from July to September. Seeds sown in March and April produced a high root yield (21.4 to 37.8 t/ha). Seeds sown in October and November gave a low yield due to frost attack. However, as the trial was conducted only for one season the results were not conclusive.

Thinning:- Thinning is not practiced in production areas such as the SNNPR, and central highlands of Bale and North Shewa zones which often broadcast seeds. Instead, they allow the plants to grow densely and harvest in two cycles. In the first cycle (60 to 75 days after sowing) only those which attained significant size are harvested. Others which are thin are allowed to further grow in the field for a second cycle harvest (90 to 120 days after sowing). However, farmers in Arsi and east Hararghe zones where they practice row seeding, try to thinly drill seeds and also thin-out if plants are crowded. Otherwise, these farmers are aware that densely grown plants could lodge, produce thin roots and give low yield. Thinning is done during first weeding. In Tigray region where farmers broadcast seeds, thinning is done at first cultivation from 21-28 days after sowing.

Carrot seedlings are very susceptible to weeds especially at their early stage before they cover the ground. Therefore, weeding and cultivation is done two to three times until the canopy covers the ground in order to suppress weeds and earth up roots to protect them from direct sunlight which causes them to green.

Fertilization:- Most farmers in Arsi and North Shewa zones do not use inorganic fertilizers in carrots. They, however, apply decomposed farm yard manure to carrot fields before ploughing the land. Farmers in the SNNPR apply from trace to 100 kg of diammonium phosphate (DAP) split into two; the first half applied at sowing and the remaining after first harvest. Farmers in

Tigray region apply 4-5 t/ha of manure at ploughing, 100 kg/ha DAP at planting and 50 kg/ha Urea at first cultivation.

A field experiment on an organic fertilizer *orga* (~23% P_2O_5 and 21% CaO) from National Fertilizer Manufacturing PLC. (NAFMAC, Germany) was tested in south Wello (Hailu *at al*., 2008). *Orga* is made up of bones, stomach paunch, horns and hooves by the action of phosphorus stabilizing and nitrogen fixing bacteria. The study revealed that the application of 309 kg/ha of *orga* supplemented with 274 kg/ha of Urea (46% N) increased root yield of carrots (var. Nantes) by 32.6% compared to the non-fertilized control and by 29.2% compared to the sole application of the same amount of *orga*. Further addition of Urea from 68.5 to 411 kg/ha did not increase carrot root yield. However, the experiment lacked a sole Urea control and the differences seemed to come from Urea fertilization.

Harvest and post harvest:- In areas that harvest all-at-once, harvesting is done from 90 to 120 days after sowing depending on the agroecology (temperature) of the growing area. In areas which harvest twice, the first harvest is done 60 to 75 days after sowing and the second 90 to 120 days after planting. Carrot yield of the Nantes variety ranges from 6 to 15t/ha under farmers management depending on agro-ecology.

Carrots are usually lifted from the ground by hand if the soil is still wet. In dry periods, harvesting is done with the assistance of hand tools. They are then topped, washed and filled in poly-bags and transported to roadsides where merchants can easily access products or to nearby markets. Washing is often done in rivers. Packing is done in poly-bags of 100 kg capacity (locally called *Fidamo*) or 150 to 170 kg capacity (called *Wosla)* depending on locality. *Wosla* has been discouraged by transporters because of over load to trucks and *Fidamo* is becoming more common. Carrots from most areas are washed before packing; however, those from South Wello (Hayiq area) are packed without being washed. These carrots are washed by retailers. In Tigray region, carrots are packed in 50 kg poly-bags.

In areas of high production, merchants travel up to farmers' fields to buy carrots and transport using medium sized (5 tonnes) trucks. Those who produce in small quantities, however, transport on horse/donkey backs, horse/donkey carts, or using own labour.

Grading of carrots is limited to separating small sized carrots which is estimated to be between 5-10% depending on the management of the farmers. The selected roots are sold to Addis Ababa market whereas the small sized roots are sold locally at nearby markets or consumed at home.

Storage:- Carrot roots cannot be stored for long after harvest. But in cases when products are in high supply but prices are low, farmers delay harvesting and leave carrots in the soil for about one to two month(s). Field storage is practiced when no more rains are expected after

maturity, otherwise, carrots over-mature in size, crack and lose quality. Field storage is not practiced during the short rainy season (*Belg*) when farmers need their land to plant grain crops in the subsequent long rainy season.

A zero energy cool chamber was adapted from India at Adet Agricultural Research Center. It is a double walled storage structure made of bricks and a roof made of wood and grass (Fantahun *et. al*., 2004). The 15 cm cavity between the walls was filled with wet riverbed sand and watered daily. The structure could keep Nantes carrot roots for three weeks with only 9% loss whereas unbagged carrot roots stored at room temperature were completely damaged. The storage structure was targeted to vegetable growers and traders who can store large quantities of vegetables and fruits. However, the technology has not been popularized due to its high cost and weak extension efforts.

Diseases and insect pests:- Leaf blight *(Altrnaria dauci*) caused a great damage to carrots (IAR, 1979). The disease was also recorded in former administration regions of Shewa and Kefa (Awgichew Kidane, 1993).

Recently, Hussien (2006) surveyed the major carrot growing regions of Hararghe (eastern Ethiopia) from 1999 to 2003. He recorded root-knot nematode (*Meloidogyne* spp.), leaf blight (*Alternaria dauci*), powdery mildew (*Oidium* spp.), as diseases of carrots. Moreover, a parasitic weed (*Orobanche minor*) is reported to be an important weed problem in Ethiopia. Root-knot nematodes and powdery mildew severely affected most of the plants and damaged their leaves in low altitude areas. Early blight was moderately severe on carrots grown at mid-altitude (1960 masl). Root-knot nematode was one of the threatening diseases recorded on a wide range of hosts mainly due to lack of crop rotation in the region.

Cutworms (*Agrotis* spp. (Lepidopetra, Noctuidae) are minor pests at the early seedling stage of carrots and hence no control measures have been taken. However, crop rotation and thorough soil preparation are some of the suggested control measures.

Leaf blight control measures include the use of selected and treated seeds. Seeds can be treated with copper fungicides at the rate of 1 to 2 table spoons in 4 l of water. Crop rotation, use of resistant varieties, destroying infested crop residues, avoiding sowing during heavy rain months were some of the suggested control measures (IAR, 1979). Farmers in major carrot growing areas of Ethiopia do not at all use chemicals to control carrot diseases and insect pests.

Marketing:- There is a wide variation in the price of carrots in different seasons. The price of a *Wosla* of carrots ranges from 150 to 300 Birr (1 Birr = ~0.18 USD) from July to October when supply is high from *Belg* and *Meher* harvests. The price rises up to 700 Birr during scarce supply between December and February and afterwards when fewer farmers produce carrots under irrigation. Production of carrots during September-December in the Arsi highlands and similar

areas with extended *Meher* season rains fetches good prices but it has the risk of terminal low water stress and thus lower yields.

Carrots are sold all over the country in woreda, zonal and regional towns and in Addis Ababa. Addis Ababa is the largest market destination for carrots from as far as Arsi (Tiyo, Bekoji, Shirka and Enkolo Wabe woredas), North Shewa (Debre Brehan and Molale), South Welo (Hayiq), Jimma and Wolayta. Carrots produced in the eastern part of Ethiopia are sold in the town of the region such as Dire Dawa, Harar and Jijiga as well as to the neighbouring countries of Somalia and Djibouti.

The annual average retail and wholesale price margins of carrot was 69% and 76%, totalling to 197% in major urban centres in 1988, better than that of potato, onion, garlic, chilli and tomato; *i.e*. the total trade margins between farm gate price and retail price was 197% (Yohannes Agonafer, 1994).

Experiences in Carrot Seed Production

The production of vegetables in general and of cool season vegetables (carrots, beets, cabbage, etc) in particular is constrained by the lack of a sustainable improved seed supply. Production of these crops is exclusively dependent on imported seeds. The import value of vegetable seeds to Ethiopia has increased more than fourteen folds from 209 thousand USD in 1997 to 2.89 million USD in 2009 (Fig 1).

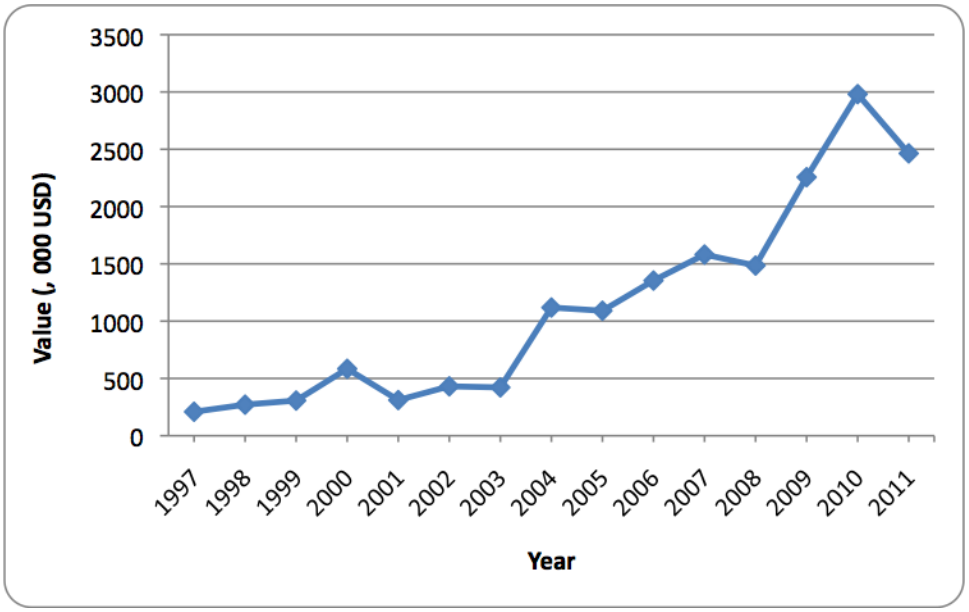

Figure 1. Value of vegetable seed import to Ethiopia in the years from 1997 to 2011
Source: www. erca.gov.et

Consequently, seed production trials were initiated in the cool highlands of Ethiopia with objectives of saving foreign currency, reducing seed costs and avoiding import of poor quality seeds and associated phytosanitary risks. These areas are known to have vernalizing temperatures during October to January which enables cool season vegetables to initiate flower buds and subsequently bolt and flower. On the other hand, the warm dry period (February to June) is suitable for seed maturity (Semagn and Fantahun, 2010). However, occasional light frost occurs in these areas during the October-January period affecting the quality of seeds. Consequently, the root-to-seed method of seed production, a two phase production method, was adopted to adapt to such incidents. The method involves production of roots in the first season, sorting for best roots and then planting the roots to produce seeds.

Attempts to produce carrot seeds from an adapted variety (Nantes) were started at Holeta, Bokoji, Meraro and Alemaya (IAR, 1977; IAR, 1986). A single observation trial was conducted on 36m^2 plots at Bokoji (2700 masl). The roots which were grown at Nazareth (1600 masl) were planted at Bokoji on 22 June 1978 at a spacing of 90 cm between rows and 40 cm between plants. The plants flowered on 22 November 1978 and harvesting was started on 6 February 1979 and ended on 30 May 1979. The resulting seed produced had 81% germination. The seeds produced at Bokoji were planted at Kulumsa (240 masl) to test if they could produce good quality edible roots and for similarity to the parent Nantes. The seeds gave roots with reasonable size, shape and taste. However, it produced 10% off-types with white roots and early bolters. Seed production studies made at Holeta were not successful due to bolting problems (Sirak Beyene, 1992).

Recently, seed production research efforts in the highlands of Ethiopia especially at Bokoji and Meraro (Arsi highlands), Lai Gaint (South Gonder highlands) and Ankober (North Shewa highlands, 3100 masl) showed that seeds of cool season crops including that of carrot could be successfully produced (Fantahun *et. al*., 2003 and Semahegn *et. al*., 2008). Seed yield and percent germination of seeds produced from domestic seeds was slightly higher than imported seeds.

A follow-up study conducted to evaluate the first and second generation of locally produced seeds of carrots var. Nantes for the production of roots and seeds compared to those of imported seeds at Ankober (3100 masl) during 2002-2003 and 2005-2006 (Semagn *et. al.*, 2008) revealed that carrots grown from first generation locally produced seeds gave a slightly higher total root yield and had greater root length than that of the imported seeds (Table 5). Unlike that of first generation locally produced seeds, carrot plants grown from second generation locally produced seeds gave slightly lower marketable and total root yields than plants produced from imported seeds. The low seed yield of the second generation seeds might be

due to occurrence of severe frost during the production of the first generation of locally produced seeds.

Carrots gave about 1000, 1070 and 586.2 kg/ha seeds at Meraro, Lai Gaint and Ankober, respectively (Lemma *et. al*., 1994; Fantahun *et al*., 2003 and Semagn *et al*., 2008).

Table 5. Root and seed yield of first and second generation Nantes carrot grown at Ankober during 2004 and 2005/6

Carrot	2003/04		2005/06	
	Local 1st generation	Imported	Local 2nd generation	Imported
Root yield (q/ha)	175.42	153.89	181.7	215.17
Root length (cm)	13.07	12.27	16.07	15.77
Root diameter (cm)	3.67	3.40	3.44	3.61
DM (%)	9.06	11.42	10.01	11.99
Number off types	3.0	00.00	0.67	0.677
Cortex –core ratio	-	-	2.25	1.97
Seed yield (gm^{-2})	8.04	2.91	4.43	3.82

Source: Semagn *et al*. (2008)

Agronomic practices used for seed production trials:- Research results conducted in different parts of Ethiopia indicated that good quality seed could be produced from Nantes and Chantenay varieties (Lemma *et. a*., 1994 and Semagn *et al*., 2008). Carrots were grown in deep, well drained sandy loam, alluvial soils with pH of 5.7 to 7. Vertisoils however were found to be not suitable. They limited root growth, posed difficulty during harvesting and washing of roots after harvest. Seed-root-seed method was used for seed production where roots for seed were produced in the same manner as for fresh market. The roots (stecklings) were stored until planting and planted on well drained soils to avoid the development of bacterial soft rot when there was no danger of frost. The soil was well firmed around the roots and the crown was level with the surface. The seed to seed method was not used as it required the original seed to be of very high quality since there was no possibility of selecting the stecklings.

Roots grown for seed were planted 75 cm apart. The plants were fertilized with 175 kg/ha of DAP, which was the recommended rate for root production for fresh market (ARARI, 2005).

A wild relative of carrot (Queen Anne's Lace, *Daucus carota*) which easily cross-pollinates with carrots was found growing in the highlands of Ankober and can affect the quality of seeds and the resulting roots. Thus the surroundings of seed production fields should be free of Queen Anne's Lace within an 800 m radius (Semagn and Fantahun, 2010).

Planting date studies:- Very low temperature is a common experience from October to January in the cool highlands of Ethiopia. The low temperature stimulates flower initiation (vernalization) and the subsequent flowering and seed set. The warm temperature between February and mid September favours seed stalk development and seed maturity (Semagn and Fantahun, 2010).

Planting date studies conducted in the highlands of Ethiopia showed that carrots sown in March in Ankober (3100 masl; Fig. 2) and those grown in September in Lai Gaint gave the highest seed yield and good quality seeds (Semagn *et al*., 2008 and Fantahun *et al*., 2003).

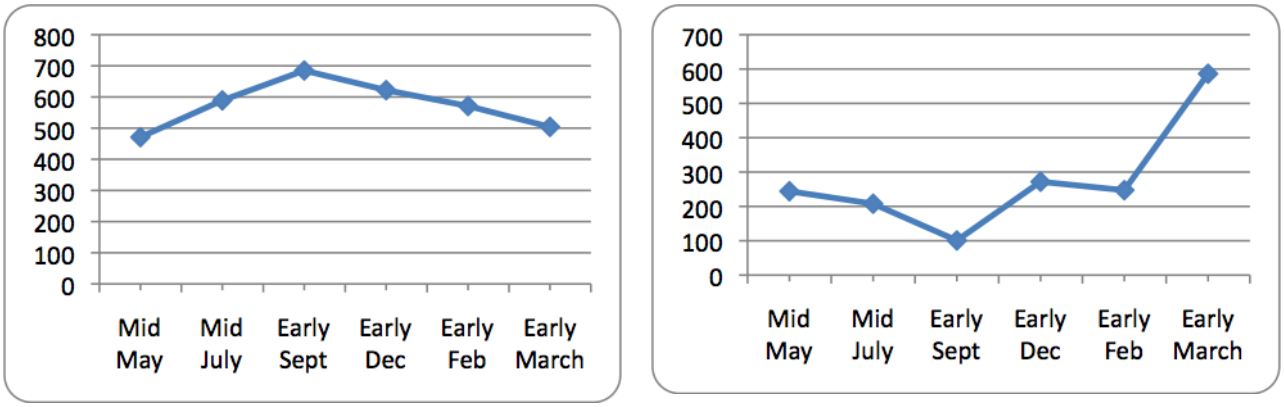

Figure 2. Days from seed sowing to first seed harvest (left) and seed yield $kgha^{-1}$(right) of carrots sown grown at Ankober (3100masl) during 2000-2001

Source: Semagn *et. a*l. (2008)

Farmers in and around Kombolcha (eastern Ethiopia) also tried and could successfully produce their own carrot seeds though in small quantities. A trial on sowing date and seeding rates of carrot for seed production was conducted in the area to assist the efforts of the farmers (Mengistu and Yamoah, 2010). Seeds of local carrots were planted at different planting dates from mid-November 2006 to mid-February 2007 at the interval of one month. Days to 50% flowering was delayed from 153 to 167 days while dates to seed maturity delayed from 244 to 267 days as sowing was delayed from mid-November to mid-February. The number of secondary and tertiary umbels, primary, secondary and tertiary umbellets per umbel decreased in mid-January and mid-February sowings compared to those in mid-November and mid-December.

On the other hand, the number of primary and secondary branches increased from 5.9 to 8.2 and 10 to 15, respectively, as plant density decreased from 400 thousand to 133 thousand per

ha. Likewise, the number of secondary and tertiary umbels per plant increased from 4.7 to 6.6 and from 6.4 to 9.7, respectively. Three to four pickings of individual branches were necessary to collect all the seeds. The branches were then put in windrows for drying and then threshed when the seed had thoroughly dried.

Moreover, Haramaya University has been testing carrot varieties obtained from Kombolcha locality for their seed production and root quality. Currently, it is in the process of verifying the variety under Kombolcha and other similar agro-ecologies.

Opportunities and Constraints in Carrot Production and Research

Opportunities

- Diverse and conducive agro-ecologies that enables year round (three cycles) production
- Reliable water source and year round cultivation
- Increasing demand and price of products: With increase in population, urbanization, and awareness of consumers and price increase in animal products, the demand and hence the price for vegetables in general is increasing
- Better infrastructure (roads and telecommunication)
- Cheap labour force
- Conducive agricultural development policy.

Constraints

- Lack of improved seeds: Almost all carrot seeds are imported. Poor quality seeds that are expired and those with low germination percentage and that are not true-to-type to the variety are sold in the market. Seeds that are not true-to-type yield bolting, cracking, splitting and short roots. Seeds are also expensive. Research attempts to produce carrot seeds is not commercialized either by the government or private companies.
- Poor market information: Marketing is the major problem in carrot production especially during the *Meher* season harvest when supply is high. Merchants and brokers agree and fix the price of carrots. In such cases farmers do not have bargaining power. In addition, there are instances in which traders buy farmers' products at an agreed price on credit but pay back at a lower price than what was agreed upon.
- Research in cool season vegetables in general and of carrots in particular is very limited. Only two other varieties of carrot have been recommended after Nantes and Chantenay which were released in the early 1960s. Agronomic, post harvest and small-scale processing practices are almost nonexistent

- Extension support in carrots is very weak. Extension materials (such as bulletins, leaflets) that can easily describe the crop, its importance and production methods are not available.
- No regular supply of carrot roots. Production is low during irrigated/dry season and in years following low prices.

Recommendations and Areas of Intervention

Recommendations

- Organize carrot producers into "Carrot Producers' and Marketers' Associations" and provide them legal protection against traders and brokers so that they can procure inputs and sell products in an organized manner.
- Establish cooperatives and provide producers access to market places in major towns so that they establish their own shops to sell directly to consumers.
- Strengthen research in carrots so that new varieties, production, post harvest and processing practices will be available to farmers. In this regard linking local research institutions with other research institutions that have good experience in carrot research will facilitate the process.
- Strengthen the extension system through training and availing clear information/knowledge through different media (production guidelines, leaflets, posters using local languages and local media) on production and marketing of carrots.
- Raise the awareness of the public about the health benefits of carrots through health and agricultural extension services.
- Capacity development to carrot growers and development agents

Areas of Intervention

Table 6. Suggested intervention options to empower growers on carrot production and marketing in Ethiopia

Component	Identified major constraints	Suggested practical interventions	Suggested approach and actors
Inputs	Lack of high quality seeds of improved varieties	▪ Undertake adaptation trails for the different carrot growing agro-ecologies of the country ▪ Organize farmers to procure from trusted seed sources	▪ Work with EIAR , MoA, and government seed suppliers (AISCO and Etfruit)
	Limited capacity of local farmers to produce seed of carrot	▪ Establish vegetable seed producing farmers' group and capacitate them through training on seed production and marketing along with market facilitations	▪ Work with research institutes and MoA
Production	Limited knowledge about appropriate agronomic practices	Capacitate farmers and Development Agents for proper: ▪ pre and post harvest management practices ▪ irrigation management ▪ plant protection practices	▪ Develop production guidelines focusing on pre harvest management, irrigation, plant protection, ▪ Provide training, demonstration, etc in collaboration with WOoA, and EIAR
	Limited capacity of farmers to plan year round production cycle	▪ Identify possible carrot varietal and crop combinations for the different agro-ecologies to ensure year round production	
	Poor post-harvest management practices	▪ Promote the available post harvest management practices (product handling, storage structures) ▪ Capacitate farmers and DAs in proper post harvest management ▪ Capacitate households/women on preparation and preservation of carrot recipes	▪ Develop production guidelines on post harvest management, recipe preparation and product preservation ▪ Provide training, demonstration, etc the same WOoA and EIAR
Marketing	Limited marketing skill of carrot growers	▪ Promotion of group action for efficient marketing and improved bargaining power of growers ▪ capacitate farmers in developing/applying responsive marketing strategies to changing market conditions ▪ Facilitation of market linkages among actors and markets	▪ Work with Marketing & Cooperative Promotion offices at zonal and district level ▪ Work with town municipalities to provide access to market places ▪ Develop zonal, district and household level marketing strategy guidelines

References

ARARI. 2005. Technical guide for technicians on production of vegetables. ARARI, Bahir Dar, Ethiopia.

Awgichew Kidane. 1993. A checklist of seed-borne pathogens in Ethiopia. IAR. Technical Manual no. 5 p6.

CSA (Central Statistics Authority). 2004/5-2010/11. Agricultural sample surveys 2004/5 - 2010/11. Reports on area and production of crops (private peasant holdings, *Meher* season), Addis Ababa

De Sole G, Belay Y, Zegeye B. 1987. Vitamin A deficiency in southern Ethiopia. Am J Clin Nutr. 45:780–4.

Fantahun Mengistu, Yigezaw Dessalegn, Adame Abebe, Anteneh Abewa and Mahetemework Mamo. 2003. Cool season vegetables seed production. Agritopia. Vol. 18 No.4, EARO Newsletter.

Fantahun Mengistu, Yigzaw Dessalegn, Tesfaye Abebe, Ermias Abate, Adamte Abebe and Tsehaynesh Getinet. 2004. The potential of a cool chamber storage facility for enhancing the shelf life of fresh fruit and vegetable produce at Adet, Amhara Region, Ethiopia. Proceedings of the Eleventh Annual Conference of Crops Science Society of Ethiopia, *Sebel*, Vol. 11, 146-153.

Haile-Meskel Balcha, 2011. Experience of World Vision Ethiopia Micronutrient Program in promoting the production of vitamin A–rich foods. *Food and Nutrition Bulletin,* vol. 22, no. 4 , The United Nations University pp 366-369.

Haile-Michael Kidane-Mariam, 1969. Vegetable production. Guide for eastern Ethiopia. Experiment Station. Collage of Agriculture, Haile-Silassie I University, Debre Zeit, Ethiopia Bulletin No. 62. 42-43.

Hailu S., Seyoum, T. and Dechassa, N. 2008. Effects of combined application of organic-P and inorganic N-fertilizers on yield of carrots. African Journal of Biotechnology Vol. pp 27-34.

IAR (Institute of Agricultural Research). 1977. Horticulture Department Research Program 1977/78. Addis Ababa, Ethiopia.

IAR. 1979. Handbook on crop production and protection in Ethiopia. 1st ed. Pp 35-38. Addis Ababa, Ethiopia.

IAR. 1986. Progress report. Department of Horticulture Roots and Tuber Crops. Addis Ababa, Ethiopia. PP 12-15.

Lemma Dessalegn, Seifu G. Mariam. and Edward Herath. 1994. Seed production studies on Vegetables. *In*: Herath E. and Lemma Dessalegn (eds) Horticultural research and development in Ethiopia. Proceedings of the second national horticultural workshop of Ethiopia. 1-3 Dec. 1992. Institute of Agricultural Research and Food and Agriculture Organization. Addis Ababa, Ethiopia.

MoA. 2011. Ministry of Agriculture, Animal and Plant Health Regulatory Directorate. Crop variety register Issue No. 14. Addis Ababa, Ethiopia.

Postmus S. 1958. Report on nutritional needs of children in Ethiopia. Rome: Food and Agriculture Organization.

Semagn Asredie, Abdulwahib Aliyi, and Fantahun Mengistu. 2008. Evaluation of first and second generation locally produced seeds of cool season vegetables for vegetable and seed yield

at Ankober, Amhara Region. Pp. 21-28. *In*: Ermias Abate (ed). Proceedings of the third annual regional conference of completed crop research activities 1-4 September, 2008. Amhara Regional Agricultural Research Institute, Bahir Dar, Ethiopia.

Semagn Asredie, Abdulwahab Aliyi and Abdissa Yohannes. 2008. Evaluation of seed production potentials of cool season vegetables. *In*: Lemma D. Endale G. Haile-Michael, K.M Zenebe W. Terefe B. Asfwaw Z. and Lakew B. (eds). Proceedings of the First Conference of Ethiopian Horticultural Science Society (EHSS). 27-30 March 2006, Addis Ababa, Ethiopia.

Simon, P.W. (1992) Genetic improvement of vegetable carotene content. In: *Biotechnology and Nutrition – Proceedings of the Third International Symposium.* Butterworth-Heinemann, London, pp. 291–300.

Simon, P.W. and Wolff, X.Y. (1987) Carotene in typical and dark orange carrots. *Journal of Agricultural Food Chemistry* 35, 1017–1022.

Simret Kifle-Iyesus. 1994. Horticultural development in peasant agriculture. Pp. 29-36. *In*: Herath E. and Lemma Dessalegn (eds) Horticultural Research and development in Ethiopia. Proceedings of the second national horticultural workshop of Ethiopia. 1-3 Dec. 1992. Institute of Agricultural Research and Food and Agriculture Organization. Addis Ababa, Ethiopia.

Sirak Beyene. 1992. Review of sweet potato and other minor root crops research in Ethiopia. In: W. Godrey-Sam-Aggrey and Bereke-Tsehay Tuku. Proceedings of the 1st National Horticultural Workshop of Ethiopia, Addis Ababa, Ethiopia.

Temam Hussien. 2006. Diseases of vegetable crops and their importance in Hararghe, eastern Ethiopia. Pp117-122. *In*: Lemma Dessalegn et., al., (eds). Proceedings of the Inaugural & First Ethiopian Horticultural Science Society Conference, 27-30 March 2006, Addis Ababa, Ethiopia.

Tesfu Mengistu and Charles Yamoah. 2010. Effect of sowing date and planting density on seed production of carrot (*Daucus carrota* var. s*ativa*) in Ethiopia. African Journal of Plant Science, Vol. 4 (8)pp 270-279.

Wolde-Gabriel Z, Demeke T. Vitamin A status in preschool children in Ethiopia 1985: An estimate of national prevalence. Addis Ababa: Ethiopian Nutrition Institute, September 1985.

World Vision Ethiopia, 2000. Impact assessment of the micronutrient and health (MICAH) program of Ethiopia at mid-term. Addis Ababa: World Vision Ethiopia, May 2000.

Yohannes Agonafir. 1994. Contribution of horticulture to the national economy. Pp. 8-18. *In*: Herath E. and Lemma Dessalegn (eds) Horicultural research and development in Ethiopia. Proceedings of the second national horticultural workshop of Ethiopia. 1-3 Dec. 1992. Institute of Agricultural Research and Food and Agriculture Organization. Addis Ababa, Ethiopia.

Appendix

Appendix Table 1. List of institutions and persons dealing with carrots

Institutions	Contact Person
Research	
1. Ethiopian Institute of Agricultural Research	Getachew Tabor Mohammed Yesuf
2. Amhara Regional Agricultural Research	Fantahun Mengistu
3. Haramaya University, Facility of Agriculture, Horticulture Department	Kebede W/Tsadik
Seed supply	
1. Ethiopian Fruits and Vegetables Marketing Enterprise (Etfruit)	
2. Agricultural Inputs Supply Corporation (AISCO)	
3. Private seed companies	
Development	
1. Ministry of Agriculture	
2. Addis Ababa Office of Agriculture	Abebaw Gizaw
3. Amhara Region Office of Agriculture	
4. North Shewa Zone Office of Agriculture	W/o Aster
5. Oromiya Region Office of Agriculture	
6. Southern Nations Nationalities and Peoples Region	Zerihun
7. Enkolo Wabe Woreda Office of Agriculture	Werku
8. Bekoji Woreda Office of Agriculture	Kedir Kabeto
9. Shirka Woreda Office of Agriculture	Lemessa Terefe Muktar Nesha
10. Ganta Afeshum Woreda Office of Agriculture	Brehane Girmay
11. Enderta Woreda Office of Agriculture	Eyob Weldu
12. Enda Mokoni Woreda Office of Agriculture	Abadi Kahsay
13. Ministry of Health	
Non Governmental Organizations	
1. Japan International Cooperation Agency	
2. World Vision Ethiopia	
3. International Development Enterprise	
4. Ethiopian Horticulture Development Agency (EHDA)	