



TIGRAY AGRICULTURAL RESEARCH INSTITUTE



DESCRIPTION OF CACTUS PEAR (*Opuntia ficus-indica* (L.) Mill.) CULTIVARS FROM TIGRAY, NORTHERN ETHIOPIA

Tesfay Belay, Mulugeta Gebreselassie and Tadesse Abadi

Research report no. 1



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INTRODUCTION

Drylands constitute about 60% of the Ethiopian landmass. Drylands, of Ethiopia at least, have poor vegetation cover probably due to continuous cultivation of crops and free-grazing. These areas have a high evapo-transpiration that exceeds precipitation. Livelihoods in such environments depend on resilience to cope with uncertainties in rainfall. Part of the resilience might be the ability to identify suitable plant species that can thrive and produce yields and farming practices. Inability to identify such sorts has often led to droughts or shortages of food.

On such plant species is cactus pear, *Opuntia ficus-indica* Mill. Cactus pear is a native of Mexico but is introduced to many parts of the drier world. It has tremendous potential of adaptation to drier areas and is often considered as an invasive species. They are often mentioned in classical biological control programs (in Australia, South Africa and Madagascar) that involved the introduction of insects to control cactus invasions. Insects introduced to control cactus pear invasions are now considered as pests because they have started farming cactus pear at least in South Africa.

Likewise cactus pear, *Opuntia ficus-indica* (L.), is an introduction to Ethiopia. There are diverse views as to the ways of cactus pear introduction to northern Ethiopia. According to Kibra (1992),

missionaries introduced cactus to Northern Ethiopia around 1847 and recently Habtu (2005) reported that Muslim pilgrimage from the Middle East introduced cactus to Southern Tigray of Northern Ethiopia in 1920. It might be possible that multiple introductions to have happened.

Cactus pear is adapted to many parts of Northern Ethiopia. In Tigray alone, uncultivated cactus covered about 32000 ha of land. Farmers also maintain cactus backyards but most of the fruit harvest comes from the wildly growing cactus plantation. Cactus pear has now become an integral part of the culture and economy of Tigray people. Cactus fruits are eaten fresh in months of July to September. Cladodes are used as livestock feed and are planted for soil and water conservation purposes. Recently other uses like nopalitos, jam and carmine are introduced. Cactus fruits have also become source of income as it is currently sold at prices (@15 birr a kilogram) well above banana and orange in the supermarkets of Addis Ababa. Meaza (2009) also found a strong association of cactus holding with increased income of farmers in Kihen tabia of Eastern Tigray. The same author reported cactus pear production in backyards as the second most important option of coping with drought for farmers in Kihen tabia, safety-net being the first. Efforts that improve the management and utilization of the cactus crop in the Tigray region could help attain food security, and improve the livelihood of the cactus grower households.

Despite all these benefits there were no systematic studies or research programs that aim at improvement and development of varieties of cactus pear meant for different purposes like nopalitos, forage, fruit and other uses. In Tigray, majority of the cactus pear plantation is from the wild and are not managed at all. Even those growing at the backyards receive little attention by way of orchard management and might be difficult to talk in terms of cultivars in the absence of cultivation. But farmers that make use of the cactus pear fruits as human food and animal feed can still discriminate cactus pear types or cultivars and the discrimination is based mainly on taste, spininess, etc. For example, according to Tesfay (2004), farmers in Mehoni identified 11 cultivars while Fetien (1997) reported three cultivars identified by the farmers at Subha-saesie wereda in Eastern zone of Tigray. Highest diversity of cactus pear plant is found in Erob Wereda, eastern Tigray where farmers have identified close to 60 cultivars based on fruit and plant characters such as spininess, color, taste, shape and size (Tesfay, 2000). But there was no systematic study conducted to identify and characterize cactus pear types grown in Tigray using internationally recognized descriptors. The only exception is the attempts of Tesfay (2004), who described 11 cactus pear cultivars around Mehoni areas. No germplasm collection maintained for future breeding works too and no varieties identified for different uses. Therefore existing cactus pear germplasm need to be collected, maintained, described and useful

traits identified, before thinking of specialized utilization and introduction of improved cactus pear cultivars.

Vast cactus pear in Tigray is growing wild, with least care, and it must be cultivated if the benefits from plant are to be sustained. One likely option would be introduction of cactus into farm-lands as hedges or intercroops or alley crops and of course with improved orchard management. This approach could have the additional advantage in mitigating the impacts of climate change. There are however no known agro forestry practices that involve cactus pear in Africa except the long rows of cactus pears planted in vast areas of grasslands in Tunisia and Algeria. These all require identification and development of suitable cactus pear varieties which must start by taking stock of the available cactus pear germplasm in country and their characterization.

A study was therefore conducted with the objective to collect, maintain and describe 13 commonly growing cactus pear cultivars, identify farmers knowledge as regards local taxonomies and characteristics of cactus pear cultivars in Eastern zone of Tigray.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted from July to December 2006 in *Erob Wereda* of the eastern zone of Tigray (Figure 1 & 2). Erob has seven *Tabias* (lower administrative unit of the region), that consists of 28

kushets (villages) with a population of 31031. It is located at 14° 10'-14° 25'N and 39° 40'-39° 50'E and an altitude ranging between 1200 and 3000 m. According to *Erob Woreda* bureau of Agriculture and Rural Development sources (2005), it covers an area of about 93345 ha. The topography is undulating with hardly any flat land for cultivation. The cultivable land amounts to about 1270 ha. The average arable land in the *Wereda* is extremely low, i.e. 0.19 ha. The area has agro-pastoral farming system. Temperature of the area ranges between 15 and 30°C and rainfall ranges between 140 and 400 mm. Besides, the rainfall pattern is erratic and drought is a recurrent phenomenon. The study area predominately has sandy soil.

Site Identification

The potential cactus pear growing *Kebele*, *Weratle*, was identified in collaboration with *Erob Wereda* Bureau of Agriculture and Rural Development. The *kebele* has 13067 ha of land and a population of 3816 in 701 households. The site was known for having the first cactus pear genotypes to have been introduced to Tigray (Kibra, 1992).

Sampling

From the *kebele*, five key informants were selected to identify and collect samples of cactus pears types commonly found in the locality to determine their fruit and plant characters. Accordingly, 13 commonly growing cultivars were identified by the key informants.

Non-random, purposive sampling techniques were employed in the identification and collection of the fruits. For the purpose of fruit, cladode and plant characterization, three plants from each cultivar were considered as replicates and the cultivars as treatments.

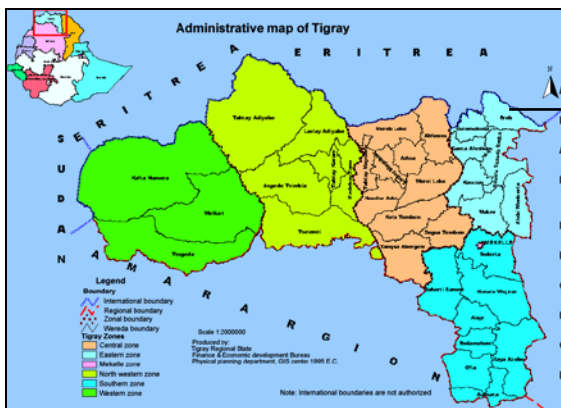


Figure1. Administrative Map of Tigray.

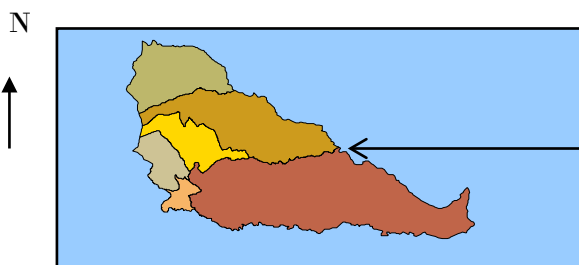


Figure 2. Map of Erob woreda, Eastern Tigray.

Experimental Procedure and Data Collection

1. Use of descriptors

Condition of the plant from which the samples were taken was recorded including local name of the cultivars, plant height, and width, plant shape, branching and growing habit.

Cladode characters including shape, length, width, thickness, color, number of fruits per cladode, spiny ness, and spines per areole was also measured.

Fruit characters measured from each plant or cultivar fruit weight, length, width, receptacular scar position, receptacular scar depth, areoles per fruit, fruit volume, pulp weight, peel weight, peel thickness, juice volume, seed weight, seed number per fruit, and % aborted seed.

Description of cultivars for vegetative, cladode and fruit characters followed the internationally accepted and standardized descriptors developed by Chessa and Nieddu (1997). Pictorial explanation for plant, cladode and fruit descriptors of cactus pear (*Opuntia ficus-indica*) are also presented in annex 1 (*Ibid*). Further chemical analysis done on the fruits includes determination of the pH, total soluble solids (TSS)) and titratable acidity (TA) (Waskar *et al.* (1999)).

2. Organoleptic test

This test was done by a panel of twenty farmers identified to be well versed in judging cactus fruit quality. The farmers tested the fruits

and were asked to make rating using a hedonic scale from zero up to five. Five being the best and zero as an unacceptable in terms of sweetness, mouth felt and crushability of seeds.

3. Estimating Productivity of the cultivars

Productivity of the cultivars was estimated according to the descriptor by Chessa and Nieddu (1997). Estimation of productivity was made by counting fruits on sample plants and taking mean fruit weight per plant for that cultivar and by multiplying with the recommended plant densities per ha. According to Inglese *et al.* (2002) the general recommendation for bushy cultivars is 2 to 3 meters along rows spaced 4 to 5 meters apart (666 to 1250 plants per ha). For the upright types, 3 to 4 meters distance along rows spaced 4 to 6 meters apart (415 to 830 plants per ha) was used. Based on these recommendations estimation in this study was made by taking the average population density of 622 plants per ha for the upright and 950 plants per ha for the bushy type of the cactus pear plants. During the study some fruits were picked prior to the count but new scars left on the cladode were considered as fruits.

3. RESULTS AND DISSCUSSION

3.1. *Cultivars Described*

Description of cactus pear cultivars growing in Erob, eastern Tigray was carried out on 13 commonly known cultivars. The cultivars with their vernacular names are presented in table 1. Names have got meanings that are associated to their taste, location, color, etc.

Table 1. Cactus pear cultivars described.

No	Vernacular name	Name associated	Meaning
1	Gerao	Taste	Sweet
2	Naharisa	Response to eating	Causes vomiting
3	Kalamile	Color	colorful after ripening
4	Adomuluhta	color and taste	white and salty
5	Geleweiti	Color	fruit with mixed colors
6	Gerwanlyele	location and taste	Name of location & watery
7	Suluhna	spiny ness	smooth (spineless)
8	Hiraydaglayele	location and taste	Name of location & watery
9	Neitsi	Color	White
10	Orgufa	Falling of fruits	falls down early
11	Ameudegaadobeless a	location and color	location & white colored fruit
12	Hawawisa	Color	looks ripen but not yet
13	Asakurkura	color and shape	red and ball shaped

3.1.1. Gerao / *Opuntia ficus-indica*

Collection number: TOfi-1

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: large (<2.1 m)
- plant shape: elongate
- habitus: upright



Cladode descriptors

- shape: ovate
- length: 35 cm
- width: 19.7 cm
- thickness: 1.5 cm
- no. areoles: 270
- spines/areole: 2



Fruit descriptors

- shape: ovoid
- size: medium(120-150 g)
- receptacle scar position: flatten
- peel color: yellow-orange
- pulp color: yellow-orange
- pulp firmness: firm
- seed number: many (>300)
- Total soluble solids: 15.33 °Brix



3.1.2. Naharisa / *Opuntia ficus-indica*

Collection number: TOfi-2

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: large (<2.1 m)
- plant shape: elongate
- habitus: medium



Cladode descriptors

- shape: elliptic
- length: 48 cm
- width: 23.00 cm
- thickness: 2.63 cm
- no. areoles: 439
- spines/areole: 3



Fruit descriptors

- shape: oblong
- size: medium(120-150 g)
- receptacle scar position: sunken
- peel color: yellow-orange
- pulp color: pale-yellow
- pulp firmness: firm
- seed number: medium (<300)
- Total soluble solids: 14.36 °Brix



3.1.3. Kalamile / *Opuntia ficus-indica*

Collection number: TOfi-3

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: medium (1.6-2.0 m)
- plant shape: elongate
- habitus: prostrate



Cladode descriptors

- shape: ovate
- length: 31.0 cm
- width: 21.33 cm
- thickness: 1.83 cm
- no. areoles: 322
- spines/areole: 2



Fruit descriptors

- shape: ovoid
- size: small (81-120 g)
- receptacle scar position: sunken
- peel color: red
- pulp color: pink
- pulp firmness: soft
- seed number: medium (<300)
- Total soluble solids: 14.06 °Brix



3.1.4. Adomuluhta / *Opuntia ficus-indica*

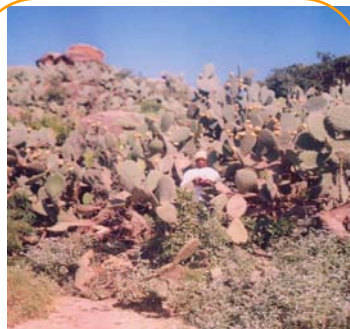
Collection number: TOfi-4

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: large (<2.1 m)
- plant shape: elongate
- habitus: upright



Cladode descriptors

- shape: ovate
- length: 33.33 cm
- width: 16.00 cm
- thickness: 1.73 cm
- no. areoles: 143
- spines/areole: 1



Fruit descriptors

- shape: ovoid
- size: small (81-120 g)
- receptacle scar position: sunken
- peel color: white
- pulp color: white
- pulp firmness: soft
- seed number: few (100-200)
- Total soluble solids: 13.50 °Brix



3.1.5. Geleweiti / *Opuntia ficus-indica*

Collection number: TOfi-5

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: medium (1.6-2.0m)
- plant shape: elongate
- habitus: shrubby



Cladode descriptors

- shape: ovate
- length: 33.00 cm
- width: 19.33 cm
- thickness: 1.63 cm
- no. areoles: 416
- spines/areole: 3



Fruit descriptors

- shape: ovoid
- size: very small (<80 g)
- receptacle scar position: sunken
- peel color: light green
- pulp color: light green
- pulp firmness: medium
- seed number: few (100-200)
- Total soluble solids: 14.66 °Brix



3.1.6. Gerwanlyele / *Opuntia ficus-indica*

Collection number: TOfi-6

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: large (>2.1 m)
- plant shape: elongate
- habitus: upright

Cladode descriptors

- shape: ovate
- length: 36.67 cm
- width: 21.67 cm
- thickness: 1.77 cm
- no. areoles: 428
- spines/areole: 3

Fruit descriptors

- shape: ovoid
- size: small (81-120 g)
- receptacle scar position: sunken
- peel color: pale-yellow
- pulp color: yellow
- pulp firmness: soft
- seed number: few (100-200)
- Total soluble solids: 14.66 °Brix



3.1.7. Suluhna / *Opuntia ficus-indica*

Collection number: TOfi-7

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: large (>2.1 m)
- plant shape: elongate
- habitus: upright

Cladode descriptors

- shape: elliptic
- length: 39.33 cm
- width: 17.00 cm
- thickness: 2.10 cm
- no. areoles: 187
- spines/areole: 0

Fruit descriptors

- shape: ovoid
- size: medium (121-150 g)
- receptacle scar position: sunken
- peel color: yellow-orange
- pulp color: yellow-orange
- pulp firmness: firm
- seed number: many (>300/fruit)
- Total soluble solids: 14.66 °Brix



3.1.8. Hiraydaglayele / *Opuntia ficus-indica*

Collection number: TOfi-8

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: medium (1.6-2.0 m)
- plant shape: elongate
- habitus: spreading



Cladode descriptors

- shape: ovate
- length: 33.67 cm
- width: 21.67 cm
- thickness: 1.83 cm
- no. areoles: 429
- spines/areole: 3



Fruit descriptors

- shape: ovoid
- size: very small (<80 g)
- receptacle scar position: sunken
- peel color: yellow-red
- pulp color: yellow
- pulp firmness: soft
- seed number: few (100-200/fruit)
- Total soluble solids: 14.50 °Brix



3.1.9. Neitsi / *Opuntia ficus-indica*

Collection number: TOfi-9

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: large (>2.1 m)
- plant shape: flat
- habitus: medium



Cladode descriptors

- shape: ovate
- length: 40.33 cm
- width: 23.00 cm
- thickness: 1.97 cm
- no. areoles: 505
- spines/areole: 3



Fruit descriptors

- shape: round
- size: small (81-120 g)
- receptacle scar position: flatten
- peel color: green-white
- pulp color: yellow
- pulp firmness: soft
- seed number: medium (up to 300/fruit)
- Total soluble solids: 15.00 °Brix



3.1.10. Orgufa / *Opuntia ficus-indica*

Collection number: TOfi-10

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: large (>2.1 m)
- plant shape: elongate
- habitus: upright



Cladode descriptors

- shape: ovate
- length: 32.33 cm
- width: 15.67 cm
- thickness: 2.03 cm
- no. areoles: 232
- spines/areole: 2



Fruit descriptors

- shape: ovoid
- size: small (81-120 g)
- receptacle scar position: sunken
- peel color: orange-yellow
- pulp color: yellow-red
- pulp firmness: firm
- seed number: medium (up to 300/fruit)
- Total soluble solids: 15.66 °Brix



3.1.11. Ameudegaadobelessa / *Opuntia ficus-indica*

Collection number: TOfi-11

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: small (<1.5 m)
- plant shape: elongate
- habitus: shrubby



Cladode descriptors

- shape: ovate
- length: 30.00 cm
- width: 20.00 cm
- thickness: 2.57 cm
- no. areoles: 295
- spines/areole: 2



Fruit descriptors

- shape: oblong
- size: small (81-120 g)
- receptacle scar position: flatten
- peel color: white
- pulp color: white
- pulp firmness: firm
- seed number: medium (up to 300/fruit)
- Total soluble solids: 16.50 °Brix



3.1.12. Hawawisa / *Opuntia ficus-indica*

Collection number: TOfi-12

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: medium (1.6-2.0)
- plant shape: elongate
- habitus: shrubby



Cladode descriptors

- shape: elliptic
- length: 34.67 cm
- width: 17.33 cm
- thickness: 1.33 cm
- no. areoles: 321
- spines/areole: 2



Fruit descriptors

- shape: ovoid
- size: small (81-120 g)
- receptacle scar position: sunken
- peel color: deep red
- pulp color: yellow-red
- pulp firmness: medium
- seed number: many(>300/fruit)
- Total soluble solids: 15.33 °Brix



3.1.13. Asakurkura / *Opuntia ficus-indica*

Collection number: TOfi-13

Maintained: Mekelle agricultural research center

Plant descriptor

Growth descriptor

- plant size: large (>2.1m)
- plant shape: elongate
- habitus: upright



Cladode descriptors

- shape: ovate
- length: 32.67 cm
- width: 16.00 cm
- thickness: 1.67 cm
- no. areoles: 411
- spines/areole: 3



Fruit descriptors

- shape: round
- size: very small (<80 g)
- receptacle scar position: flatten
- peel color: red
- pulp color: red
- pulp firmness: soft
- seed number: few (100-200/fruit)
- Total soluble solids: 15.40 °Brix



3.2. Results of organoleptic tests

An ideal cactus pear cultivar is expected to have high yield, high fruit sugar content, and be attractive to consumers. In addition to the quality parameters measured through different methods and by different instruments, a panel test by a group of farmers is also done to assess the overall organoleptic quality of the cactus pear cultivars.

According to the result presented in figure 3, *Gerao*, *Suluhna* and *Ameudegaadobelesa* cultivars were most preferred in terms of their sweetness. *Neitsi* was rated fourth for its moderate sweetness and high water content. *Gerwanlayele*, *Hiraydaglayele* and *Naharissa* were rated as the least preferred by the panelists. *Naharissa* had unpleasant taste. *Adomuluhta* was the least preferred, although it had seeds that easily crush up on eating.

Eventhough some of the cultivars such as *Gerao*, *Adomulhita*, *Suluhna*, *Ameudegaadobelesa* and *Asakurkura* had large seeds; their seeds can be easily broken. This characteristic coupled with high TSS make cultivars such as (*Gerao*, *Suluhna*, and *Aeudegaadobelesa*) interesting for further improvement.

All local cultivars described were edible but people prefer the sweet ones with crushing seeds, large fruit size and red colored flesh fruits.

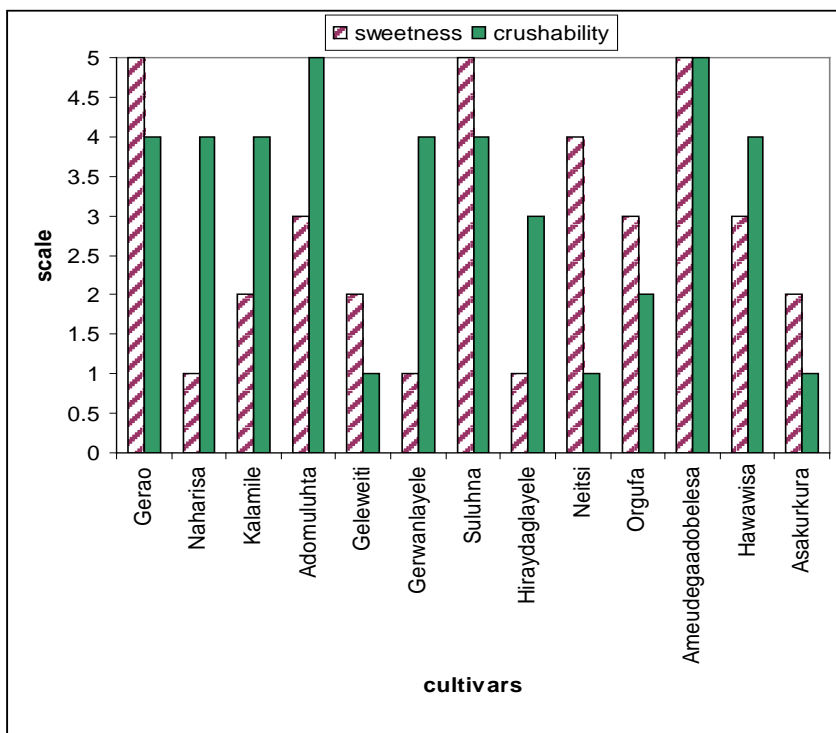


Figure 3. Organoleptic test values of thirteen cactus pear cultivars. (Scale: sweetness 0= unacceptable, 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent; crushability, 5 = crushable, 3 = medium, 1= less crushable)

3.3. Productivity Estimate of the Cultivars

Based on the estimation made from sample plants, *Neitsi*, *Gerao*, *Naharisa*, *Orgufa* and *Suluhna* cultivars were among the high yielding cultivars which produced 423, 322, 317, 278, 224 fruits per plant (Table 2). Cultivars *Adomulhta*, *Hiraydaglayele*, *Gerwanlayele*, *Ameudegaadobelesa* and *Kalamile* were medium yielding with mean fruit number range of 155 to 197 per plant; *Asakurkura*, *Hawawisa* and *Geleweiti* were found to be low yielding cultivars with 140, 101 and 82 fruits per plant, respectively. The fruit yield estimated was obtained from traditional production system, with practically least care. The cactus pear cultivars might give higher yield when grown in backyards and also with improved management.

The productivity of *opuntias* is extremely variable in different areas. In Italy Inglese *et al.* (1995) reported cactus pear fruit yield of 15 to 25 tons ha⁻¹ while yields in Chile were 6-9 tons ha⁻¹ and in Mexico 3 to 15 tons ha⁻¹ (Barbera, 1995). In South Africa Wessels (1988) reported yields of 10 to 30 tons ha⁻¹ with peaks of 33 tons ha⁻¹ obtained in experimental farms.

In this study cultivars *Neitsi*, *Gerao*, *Naharisa*, *Orgufa*, and *Suluhna* were estimated to produce higher fruit yields ha⁻¹, than Mexican and Chilean cultivars. In general, the local cultivars in the study area were comparable in their estimated yield with top South African commercial cultivars. Therefore, commercial production of cactus

pear fruits would be feasible in our area after a careful selection of the suitable cactus pear cultivars.

Table 2. Estimated productivity mean fruit number and weight, spine length and spine per areole of cultivars identified in the study area

No	Cultivar	Average no. of fruits/plant (no)	Average fruit weight (g)	Estimated production (tons/ha)
1	Gerao	317.34	144.41	28.44
2	Naharisa	278.33	146.59	25.37
3	Kalamile	155.66	84.52	12.50
4	Adomuluhta	197.33	90.31	11.08
5	Geleweiti	82.30	60.02	4.69
6	Gerwanlayele	174.00	109.38	11.83
7	Suluhna	224.00	142.36	19.88
8	Hiraydaglyle	184.00	77.41	13.45
9	Neitsi	423.00	114.62	30.15
10	Orgufa	322.00	110.99	22.20
11	Ameudegaadobelesa	161.33	97.17	14.80
12	Hawawisa	101.33	119.92	11.54
13	Asakurkura	140	54.06	4.70

Yield estimation is based on plants per hectare for upright type cultivars *Gerao*, *Naherisa*, *Adamuluhta*, *Grwanlayele*, *Suluhna*, *Neitsi*, *Orgufa* and *Asakurkra* 622 plants per hectare while 950 plant per hectare was used for the remaining cultivars which are bushy types.

4. CONCLUSION

This is the first effort to domesticate cactus pear production as there is no any research program in Ethiopia that dwells on improvement of this neglected resource. It is not complete as there are vast areas of Tigray and other regions in Ethiopia where cactus pear is abundant but not utilized and visited for germplasm collection.

Cactus pear is an introduced plant but there appears to be lots of variability partly because of sexual reproduction. In some traits like the seed number per fruits, there are some cultivars with few numbers of seeds per fruit than has been reported in its center of origin.

Information generated from the small amount of germplasm collected from eastern Tigray and maintained at mekelle agricultural research center will somehow help in the branding or marketing of cactus pear fruit as the currently produced and marketed in different cities including Addis are not branded as such.

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