Adaptation and Performance Evaluation of Prickly Pear Cactus, Opuntia ficus-indica (L.)

Reducing Land Degradation and Farmers' Vulnerability to Climate Change in the Highland Dry Areas of North-Western Ethiopia

TECHNICAL REPORT OF EXPERIMENTAL ACTIVITIES

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Implemented by

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About the Project

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Cover photo: Visiting the cactus trial in summer 2015 | 15 August 2015 |C. Zucca

About ICARDA

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Synthesis

Activity type: Technology generation

Report submitted by: Allemu Tarekegn

Summary report

The objective of the trial was to evaluate adaptation of different Cactus cultivars for fodder production in the model village of Gumara- Maksegnit watershed. Livestock feed shortage as a result of grazing land degradation and crop failure due to shortage and poorly distributed rain is critical in the Gumara- Maksegnit watershed. To assuage this problem identifying and planting feed crops with high water use efficiency (Cactus) that produce acceptable yield has to be considered in the watershed. An experiment was conducted to evaluate the adaptability and productivity of different Cactus cultivars under the ecological conditions of Gumara- Maksegnit watershed in the year 2012/2013 for 15months. Five cultivars of cactus (Sulhuna, Gerao, Dilaledik, Gerwanlayele and Ameudegaado Belesa) which were collected from Eastern zone of Tigray and one cultivar (Local) collected from the watershed were used as experimental treatments. Cactus cladodes were planted at a density of 6667plants ha-1 by using a Randomized Completely Block Design (RCBD) with three replications.

To assess the adaptability and productivity percent survival of cladodes, days taken to sprout, percent of plants sprouted, number of cladodes formed per plant, size of newly formed cladodes, average weight of cladodes and dry biomass yield were recorded. The results indicated that cactus cultivars evaluated showed statistically significant variation ($p < 0.05$) in days taken to sprout, number of cladodes formed per plant, width of cladodes (cm), average weight of cladodes (g), and dry biomass yield (kg/plant) while there is no statistical significant difference ($p > 0.05$) in percent of plants sprouted, percent survival of cladodes, length of cladodes (cm) and dry matter percent of cladodes (DM%).

From the cultivars evaluated Sulhuna, Dilaledik and Ameudegaado Belesa were significantly at par but higher than others in number of cladodes formed per plant, average weight of cladodes and dry biomass production which are the best indicators of the superiority of cultivars as a forage source and adaptation of cultivars to the environment. Thus according to the results of this study Sulhuna, Dilaledik and Ameudegaado Belesa varieties are recommended for wider use in the watershed.

Schematic summary of information

Location (locality, town, province….)	Dinzaz kebele, Gonder zuria wereda,
Dinzaz site	
Northing;	1373845
Easting;	3490990
Elevation	2073m a.s.l.
Period of implementation:	Jan, 2012 to June, 2015
Duration of trials:	(4 years)
Activity leader(s):	Alemu Tarekegn
Other researchers involved:	Aynalem H., Belete Shimelash and Tikunesh Zelalem

1 Background and rationale

The major feed sources for animals in the watershed are; natural grazing and crop residues supplemented by hay and weeds. The production and productivity of natural pastures and other feed resources of Gumara- Maksegnit watershed depend up on the rainfall distribution and intensity. The production of forage and food crops is significantly reduced due to shortage of rainfall. Other factors that contribute to feed shortage are small land holdings of the farmer that lead to encroachment of the grazing lands and the production of fewer amounts of crop residues from that limited land.

Cactus pear is an introduction to Ethiopia. There are different views about the way cactus pear was introduced to Northern Ethiopia. Neumann (1997) who based his information on a Swiss geographer that carried out an extensive research in the Erob area during 1970s described that French missionaries introduced cactus pear to Ethiopia in the north east of Tigray as early as 1848. However, recently Habtamu (2005) reported that Muslim pilgrimages from Mecca (Saudi Arabia) introduced cactus pear to the lowlands of Southern Tigray in 1920. Now, cactus pear is widely spread throughout the Tigray region and is believed to cover more than 30,000 hectares of land (SAERT, 1994). It has, of course, become source of nourishment for several people during the summer months when there is shortage of cereals and other food crops.

Cactus pear is also found in North Gondar zone of Amhara region particularly in the Gumara-Maksegnit watershed. However, its productivity and popularity as human and animal feed is relatively low compared to that of Tigray. Feeding of Cactus for the livestock is not a common practice in the watershed but some farmers practiced cactus feeding intentionally when they want to de- warm their animals. But now a days the demand for

prickly pear cactus pad as animal feed in the watershed is increasing through time as drought and land degradation increases. Farmers currently show an interest to plant prickly pear cactus around their hay store and farm boundary to use primarily as a live fence and secondly as the standing feed resource to enable animals especially goats survive critical periods of prolonged drought and dry season, which presently cannot be used for other crops, due to its steep slope or stony soils.

Northern Ethiopia, particularly Tigray, is known for its crop failures due to shortage and poorly distributed rain. So, identifying crops with high water use efficiency that produce acceptable yield is a priority for the area (Fetien, 1997).

In arid and semi- arid environments, not only feed but also drinking water is a real problem for animal production. To assuage this problem farmers in drought prone areas, have developed a system of infrequent watering, by supplying water every two and three days. Although, such practice seems to benefit farmers to save water, time and labor spent in search of water, it significantly affects the productivity of animals. Cactus, in this regard, has been playing a great role in saving water problem.

2 Objective

The main objective of this research activity was to evaluate the adaptability of different Cactus cultivars for fodder production in the model village of Gumara- Maksegnit watershed.

3 Experimental Methods

Study Area Description

The study was conducted at Gumara-Maksegnit watershed of Gondar Zuria woreda; 45 km south east of the Zonal capital Gondar (lat 120 25' 14.8'' N, long 0370 36' 18.5'' E) at an elevation of 2061m. a. sl. The soil texture of the study area is sandy, poor in water-holding capacity and fertility. The area has a moist tropical climate and the mean monthly maximum temperature ranges from 25.3 °C to 32 °C with a mean value of 28.5°C, while the mean monthly minimum temperature ranges from 10.6 °C to 16.1 °C with a mean of 13.6 °C. Based on 20 years (1987-2007) data, the total annual rainfall ranges between 641 mm and 1678 mm with a mean value of 1052 mm. Farmers reported that the rainfall is small in amount, unpredictable in onset and cessation and poorly distributed. This nature of the rainfall is heavily influencing crop production and livestock husbandry and thus farmers' livelihood. The topography of the area ranges from gentle slope to sharp steep slope. The watershed is inhabited by 1148 households and 4246 individuals with an

average family size of four persons. Settlement in the watershed is scattered and the landholding is characterized as small and fragmented. About 55% of the total land is cultivable, 23% of the area is covered by forest and grazing land, 7% is west land and 15% of the land is used for settlement. Livelihood of households in the watershed is dependent on forests, livestock and crop production (Yonas, et al., 2010).

Approach

For the plantation of cactus we asked the land from the community and development agents and they discuss and decided to allocate a land in the protected part of the watershed that normally is considered unsuitable for other crops.

Cladode Collection

One-year- old cladodes of the five cultivars of Cactus pad cuttings were collected from Ganta-afeshum and Erob Woredas, Eastern zone of Tigray region, 882km north of the country's capital where Productive cultivars of cactus found and one cultivar of local cactus also collected from the watershed. From each woreda and site, six prickly pear cactus cultivars were selected that were clearly separated from other cultivars and had 10 to 12 cladodes connected at the base only to a previous- year cladode. These selection criteria were established to ensure cladodes were cultivars and that there were an adequate number of cladodes to select sufficient number of that were healthy, similar to each other in size and age. Each cladode was cut using a disinfected knife by using alcohol and placed in a seedling tray for ease of transportation. Cladodes were collected in late April and placed in well ventilated condition.

Table 1: Cactus pear cultivars collected for evaluation in Gumara- Maksegnit watershed, North Gondar

S.No	Vernacular name (in Erob)	Name associated to fruit and cladode character	Meaning
1	Gerao	Taste	Sweet
2	Gerwanlayele	Location and taste	Gerwan is location in the village and layele is its watery teste
3	Sulhuna	Spiny ness	Smooth (Spineless)
4	Ameudegaado Belesa	Location and color	Ameudega is location in the village and adoBelesa means white colored fruit
5	Dilaledik	Location	Mostly found in and around apiary sites

4 Statistical aspects

Treatments and experimental design

The six cultivars of cactus they were collected and planted were Sulhuna, Gerao, Dilaledik, Gerwanlayele, Ameudegaado Belesa and Local. In the field, the 6 cultivars of cactus cuttings were distributed in a randomized complete block design with three replications, using 15 plants per plot as an experimental unit.

Evaluation of under Planted Cactus Cuts

Prior to planting, the cladodes were dried for 2 weeks under partial shed to allow healing of the cutting area and then planted upright. During planting the flat edges face east and west and the thin sides face north and south. This way the sun will hit the slimmest part of the cladodes during the hottest part of the day and prevent sunburn. Mature pads of cactus (26cm long and 21cm wide) were planted at a spacing of 1.5 X 1.0m in to the holes of about 9cm deep and firmed with the soil so as to buried one- third of their surface area below ground and two- third above the soil surface with a density of 6,667plants ha-1. Plot size was 5 X 4.5m to hold 15 plants in to three rows. Planting was done during the end of dry season in May 2012 to ensure maximum establishment. Prior to planting clearing of impediments, digging holes and making the soil fine was done to ensure good establishment. Establishment observation on the establishment of the cactus pad cuttings were made after 3 and 6 weeks from planting. The total number of cuttings which had sprouted was determined. Common cultural practices related to weeding and plant protection measures were followed.

- Statistical design: after planting in the field their performance was evaluated with respect to days taken to sprout, percent of plants sprouted, percent survival of cladodes 6 months after planting, number of cladodes formed per plant, size of cladodes (cm), average weight of cladode (g), biomass yield (kg/plant) and dry matter percent (DM%) of cladodes (Table 3) and (Table 4).
- Statistical analysis: the data collected was subjected to analysis of variance by using the general linear model (GLM) procedure in SAS (2003)

5 Results and discussion

Percent survival of cladodes 6 months after planting

There is no significant statistical variation between the cactus cultivars in percent survival ($p > 0.05$) (Table 3). On average, cactus pears had higher survival rate after 6 months of planting. On an individual basis, the survival rate of cactus pears ranged from 77.78% in Sulhuna to 97.78% in Gerao cultivars with the mean value of 88.89%.

Days taken to sprout

Data presented in Table 2 revealed that cultivar Dilaledik took the minimum period of 72 days for sprouting while the maximum period of 172 days was taken by cultivar Sulhuna. However, most of cultivars (3 cultivars) sprouted in 86 to 136 days and the local cultivar sprouted after 169 days. Earlier sprouting seems to be related to the warmer conditions during the months of May and June which is favorable to sprouting to the respective varieties.

Percent of plants sprouted

There is no significant statistical variation in average percent of plants sprouted till 6 months ($p > 0.05$). The average percent of plants sprouted (Table 2) was a maximum of 97.78 %, and was higher than other cultivars in the case of Gerao and Dilaledik, followed by Sulhuna (91.11%). Cultivar Gerwanlayele recorded 88.89% average percent of plants sprouted, while local cultivar recoded lower average percent of plants sprouted (77.78%) till 6 months in the field.

Table 2: Percent of plants sprouted, days taken to sprout and survival of cladodes after 6 months of planting

Treatment	Percent of plants sprouted till 6 months	Days taken to sprout	Percent survival of cladodes after 6 months
Sulhuna	91.11	172[a]	77.78
Gerao	97.78	86[d]	97.78
Dilaledik	97.78	72[e]	95.56
Gerwanlayele	88.89	136[b]	93.33
Ameudegaado Belesa	80.00	104[c]	91.11
Local	77.78	169[a]	82.22
Mean	88.89	123.13	89.63
LSD (0.05)	NS	5.13	NS
CV (%)	24.2	2.29	17.69

*Means followed by different superscript letters with in a treatment group are significantly different at ($p < 0.05$).

Number of cladodes formed per plant

Mean number of cladodes formed per plant of the six Cactus pear cultivars evaluated was statistically significant ($p < 0.05$). Cultivar Sulhuna produced the maximum (5) cladodes per plant at 15 months of age (Table 3), closely followed by cultivar Dilaledik (4.22) and Ameudegaado Belesa (3.89). The number of cladodes was minimum in cultivar Gerwanlayele (3.17), followed by Gerao (3.33) and Local (3.44). Both were significantly at par but lower than others. Singh and Salanki (1999) reported that in arid environment most varieties grows profusely when provided with sufficient water and fertilization during early stages of growth. However, under present site conditions sufficiently large damage by rats and termites in Gerao, Gerwanlayele and Local cultivars was noticed, and growth was affected adversely. The fleshy nature of cladodes due to higher moisture content in these cultivars encouraged damage by these pests.

Average weight of cladodes

The average weight of cladodes (Table 3) was a maximum of 497.22g, 479.22g, 386.09g and 375.24g and was significantly higher than other cultivars in the case of Sulhuna, Ameudegaado Belesa, Dilaledik and Gerao respectively. Local and Gerwanlayele varieties recorded 280.56g and 200.01g average weight and both are at par, while these cultivars recorded significantly lower average weight than others.

Size of newly formed Cladodes

There is no statistical significant difference between cactus varieties in length and width of newly formed cladodes ($p > 0.05$) (Table 3). The length of cladodes varied from 18.65cm in Gerwanlayele to 25.78cm in Ameudegaado Belesa (Table 3). Four cultivars (Ameudegaado Belesa, Gerao, Dilaledik and Sulhuna) produced cladodes of over 22cm length and two cultivars (Local and Gerwanlayele) of less than 20cm length. The width of cladodes in different varieties varied from 11.03cm in Gerwanlayele to 14.7cm in Ameudegaado Belesa. Four cultivars (Ameudegaado Belesa, Sulhuna, Gerao and Dilaledik) had cladodes 12cm and more in width. Thus, the size of cladodes in different varieties varied. Cultivar Ameudegaado Belesa, Sulhuna and Gerao had very large cladodes. Such variation in size of cladodes by other cultivars has also been reported by (Anon, 1992 and Singh 2000). There is no statistical significant variation among cultivars in length to width ratio ($p < 0.05$).

Dry biomass production

Biomass production 15 months after plantation was significantly higher in Sulhuna (2.75kg/plant) and Ameudegaado Belesa (1.90kg/plant) followed by Dilaledik (1.63kg/plant), while Gerwanlayele and Local varieties produced significantly lower biomass than others.

Percentage dry matter of cladodes

The percent dry matter (DM %) in the cladodes differed not significantly (p >0.05) between the varieties and ranged between 12.81% (Gerwanlayele) and 13.62% (Local) (Table 3). In contrast, according to Lopez- Garcia et al. (2001) the total amount of water stored in the cactus pear cladodes depends upon species and varieties. Clearly from this study, percent dry matter in the cladodes is also strongly influenced by environmental conditions, which can, according to Lopez- Garcia et al. (2001), ranged between 30% and 7%.

Table 3: Mean value of yield and yield components of different Cactus varieties evaluated at Gumara- Maksegnit watershed

Treatment	Number of cladodes formed per plant	Size of cladodes		Length to width ratio	Average weight per cladode (g)	Dry biomass yield (Kg/plant)	Dry matter percent (DM%) of cladodes
		Length (cm)	Width (cm)				
Sulhuna	5.0^{a}	22.61	13.92^{ab}	1.64	497.22^{a}	2.75^{a}	13.19
Gerao	3.33^{b}	23.04	12.92^{abc}	1.77	375.24^{ab}	1.18b^{c}	13.08
Dilaledik	4.22^{ab}	22.88	12.52^{abc}	1.83	386.05^{ab}	1.63^{ab}	12.90
Gerwanlayele	3.17^{b}	18.65	11.03^{c}	1.69	200.01^{bc}	0.65^{c}	12.81
Ameudegaado Belesa	3.89^{ab}	25.78	14.70^{a}	1.75	479.22^{a}	1.90^{ab}	13.34
Local	3.44^{b}	19.87	11.62^{bc}	1.71	280.56^{bc}	0.98^{bc}	13.62
Mean	3.84	22.14	12.78	1.73	369.71	1.48	13.15
LSD (0.05)	1.15	NS	2.43	NS	156.59	0.95	NS
CV (%)	16.45	13.25	10.44	8.49	23.28	25.23	5.35

6 Conclusions and recommendation

Despite its drought tolerant and ability to grow in a poor fertility status soils, Cactus will be the best alternative feed resource in the Gumara- Maksegnit watershed. According to the results of this study cultivar Sulhuna, Dilaledik and Ameudegaado Belesa gave the highest number of cladodes per plant, average weight of cladodes and dry biomass yield, which are the best indicators of the superiority of cultivars as a forage source and adaptation of cultivars to the environment. Thus we can conclude that these cactus cultivars are adaptive and productive for Gumara- Maksegnit watershed area. Hence these varieties can be used as an alternative feed source especially during the dry season for ruminant livestock to minimize the burden of feed shortage in the area and these cultivars should be widely demonstrated to the farmer in the watershed. Note: in the last experimental year (2015) the experiment was damaged, for this reason the 2015 data couldn't be properly collected.

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***NOTE**: The data presented in this report are currently being elaborated for scientific publication, thus some of them are not final. The aim of this report is to summarize the nature and quality of the activities conducted and of the dataset generated, and to illustrate the main results obtained.*

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