

Thornless cactus: an unconventional, valuable fodder resource

in arid region of India

Rahul Dev¹, Devi Dayal², Shamsudeen M.³ and O. P. Yadav⁴

Regional Research Station, Central Arid Zone Research Institute, Kukma, Bhuj (Gujarat) 370 105

Cactus pear (Opuntia ficus indica), is regarded as the future forage crop in drylands of India owing to its ability to produce increased dry matter under limited water condition through a specialized photosynthetic mechanism called Crassulacean Acid Metabolism. There are more than 150 districts in India which suffer from several problems i.e. higher grazing than carrying capacity, adverse site factor, poor management, degraded condition and poor productivity. Cactus has tremendous potential to augment forage production because it is easy to establish, maintain and utilize as a fodder crop and able to withstand prolonged droughts. Green cladodes of cactus pear are source of low-cost livestock feed during driest during March-June, when nothing is available for grazing. The initial field evaluation of cactus accessions indicated that different accessions varied significantly with respect to different growth characteristics and yield. In one year of growth in the field, these cactus accessions produced above ground green biomass of 7.8 to 19.3 tonne/ha. Nutritional quality analysis showed that the crude protein content ranged from 4.22 to 11.88%, crude fibre from 12 to 19% and total ash from 15.65 to 26.15%. This crop is unexploited commercially so far in India, with a few exceptions and there was limited attempt to cultivate this plant as a horticultural or fodder crop in India.

Key words: Cactus, Crassulacean Acid Metabolism, Dryland, Fodder, Thornless, Water use efficiency

DRYLANDS in India comprised of arid, semi-arid and dry sub-humid regions, are characterized by increased variability in amount and intensity of rainfall along with the occurrence of varied periods of drought. In view of bioclimatic, anthropo-livestock and land deterioration scenario, cactus pear (*Opuntia ficus indica*), become highly suitable for fodder production in arid and semi-arid zones and can survive in areas where no other fodder vegetation able to grow. Due to its ability to produce increased dry matter under limited water condition through a specialized photosynthetic mechanism called Crassulacean Acid Metabolism, it is regarded as the future forage crop in the drylands of

India. Green cladodes of cactus pear are source of low cost livestock feed during driest of the season (March-June) when no green fodder is available. Cactus pear is adapted to extreme climatic conditions. Cactus pear can be grown in degraded and marginal soils as well in soils which are not suitable for most of the other crops. Its well-developed root system prevents soil erosion caused through wind and water and allows to grow in marginal soils. Compare to various important food and fodder crops, cactus is easy to establish, maintain and utilize as fodder crops. Once established in the field, it can produce a very high green fodder yield (up to 250 tonne/ha). An additional advantage of cactus pear over

common fodder like barley and maize is that over consumption of cactus cladode will not generate acidosis in ruminant because of its high content of mucilage in cladodes which increase insalivation and prevent a drastic decrease in rumen pH. Thornless cactus belongs to family Cactaceae having 122 genera and 1,600 species and is native to Mexico. The genus *Opuntia* contains 180 species, of which three widely cultivated species are *O. albicarpa*, *O. ficus indica* and *O. robusta*. *O. ficus-indica* is creeping or upright shrubs that can grow between 3.5 and 5 m height. The root system is extensive, densely branched and with many fine shallow absorbing roots highly suited to arid zones. Several thornless

varieties of *O. ficus indica* are available that have promising multipurpose use as fodder and forage for livestock consumption, fruit and vegetable use for human beings, and other industrial uses. This crop is unexploited commercially so far in India, with few exceptions.

Cactus as a fodder crop in arid regions

The production and life support systems in arid regions are constrained by low and erratic precipitation (10 to 420 mm/year), high evapo-transpiration (1,500-2,000 mm/year), frequent droughts with poor soil physical and fertility conditions. Suitable crops for these areas must withstand these edaphic and climatic production constraints. The cactus pear fit most of these requirements:

- (a) Relatively drought-resistant, survive long droughts and produce large quantities of fodder.
- (b) Supply succulent fodder to animals during droughts.
- (c) Tolerate severe fodder utilization and have high recovery ability after every cut of cladodes.
- (d) Tolerate a wide range of soil and climatic conditions.
- (e) More efficient than grasses or legumes in converting water to dry matter, based on their specialized photosynthetic mechanism.

Water use efficiency is about 3-fold higher than found for highly productive C 4 plants (such as maize or sugarcane) and 5-fold higher than for highly productive C 3 plants (such as alfalfa, cotton, or wheat) under similar environmental conditions (Table 1).

Another remarkable characteristic

of this plant is that the peak biomass accumulation period in India is between March and May, which coincides with the season of extreme deficiency of fodder. In drought periods, cattle have to walk long distances to get water. By consuming 40 kg/day cactus containing about 85% water, cattle are also consuming about 35 litres/ day water, which can be beneficial in drought periods.

Cactus as a fodder bank

Large-scale plantation of cactus can provide a considerable reserve of animal feed during drought periods. Plantation of cactus in the marginal and unutilized land with proper initial care helped to combat erosion and desertification and provide feed for livestock during drought. A large portion of cactus pear plant biomass is vegetative material rather than fruits, and it can be fed to livestock as fresh forage or stored as silage for later feeding. The cactus pear can be used for all year round, or as emergency feedstock during drought.

Suitability of cactus pear in India

There are more than 150 districts in the country which are highly drought prone. This crop has tremendous potential to augment forage production in these areas because it is easy and cheap to grow, palatable, and able to withstand prolonged droughts. In India, regions with rainfall up to 700 mm are suitable for cactus cultivation.

Introduction and evaluation of cactus pear

Considering its potential as a fodder crop in many parts of arid and semi-arid regions of the world, the cactus pear was first introduced for evaluation in the 1970s by the researchers at Central Arid Zone Research Institute, Jodhpur. Subsequently, Nimbkar Agricultural Research Institute (1987), CSSRI, Karnal (1991), CIAH, Bikaner (1997) and CAFRI, Jhansi (1998) introduced and evaluated cactus accessions for its growth and potential yields. However, a new impetus on cactus research was made between 2012 and 2014 when ICARDA provided about 65 cactus

accessions to CAZRI, Bhuj, Gujarat and 49 accessions to IGfRI, Jhansi for its multilocation evaluation as fodder crop.

Survival, growth and yield: There was wide variation in survival, growth and yield of cactus under different agro-eco-regions of the country. The studies at CAZRI showed that three-year-old plantation of cactus planted at 3 m × 2 m produced 30 tonne/ha fresh biomass. The survival recorded at Jodhpur condition was about 50% whereas at Pali it ranged from 33 to 100%, Bikaner (89-93%), and Maharashtra (100%). At Karnal, the biomass yield varied from 11.5 to 30.6 kg/plant for 5 accessions, two years after planting. The biomass yield at Jhansi varied from 2.6 to 30.6 kg/plant and at Bikaner, it ranged between 1.6 and 11.6 kg/plant.

The sixty-four (64) accessions were evaluated at RRS, CAZRI, Bhuj during 2013-15, and after one year of field evaluation, the field survival rate of 90-100% was recorded. Evaluation study at the farm of Regional Station Research, CAZRI, Bhuj revealed the high potential for growing cactus as fodder crops in arid regions. After one year of the plantation at a spacing of 2 m × 2 m at Bhuj, Gujarat, cactus produced 7.8 tonne/ha green fodder. In Bikaner, Rajasthan a potential fodder yield of 19.3 tonne/ha was recorded. The cactus accessions like CAZRI Botanical Garden, Bianca Macomer, Clone no. 1270, 1271 and 1308 were identified for higher fodder yield.

Soil and climate: Cactus prefers warm summer and cool dry winter and is tolerant to high temperature and water stress. However, it is susceptible to frost. The optimum temperature for cactus pear production range between 18° and 26°C, although some species can tolerate temperatures as high as 40°C and as low as -8°C. It grows in zones with annual precipitation of 200 to 450 mm. It can not tolerate water-logging, which will lead to rotting. The plant can survive adverse soil conditions of pH up to 8.7 and salinity up to 6 dS/m. A well-drained, shallow to medium deep with light

Table 1. Water use efficiency of cactus pear in comparison to other crops

Crop (WUE)	Water use efficiency	
	kg H ₂ O/kg DM	mg DM/g H ₂ O
<i>Opuntia</i>	267	3.7
Pear millet	400	2.5
Barley	500	2.0
Sorghum	666	1.6
Wheat	750	1.3
Alfalfa	1000	1.0
Rangeland	2,000	0.5

(Sources: Le Houérou, 1994)



Fig. 1. Nursery multiplication of cactus pear at RRS, CAZRI Bhuj.

texture soils are most suitable for cactus plantation.

Planting time and method: Nursery planting can be undertaken in September-October, February-March. Transplanting is done before the onset of the rainy season to avoid rot in the cuttings. Cactus is traditionally propagated through the cutting of cladodes. Selection of medium-to-large and healthy cladodes ensures a high number of active buds. Cladodes collected from the plants are dried under shade for 8-15 days. The cladodes are initially raised in plastic pots filled with potting mixture (1:1:1 sand, soil, farmyard manure), by keeping a one-third portion of the cladode under the soil and two-thirds above the soil surface. Prior to planting the cladodes are to be treated with Bavistin (0.2%). Erect planting keeping one-third portion of cladode below the soil found to give higher survival. The nursery raised plants can be transplanted to the field when two or three additional cladodes emerge from the base cladode. Alternatively for large-scale planting dried and sprouted cladodes can be planted directly in the field in shallow holes

or on ridges of 40 cm height. In nutrient-poor degraded soils, 1 kg farmyard manure plant is recommended. Immediately after transplanting, 5 litres of water is added to each plant. Ridge or terrace planting is required, if

the site selected has poor drainage provisions as cacti are unable to withstand waterlogging. For higher fodder yield, a dense planting of either at 3 m × 3 m or 2 m × 2 m should be adopted.

Harvesting, feeding and digestibility: Cactus should not be allowed to be grazed directly by animals, as it decreases cactus plant longevity. Cut and carry method is preferred technique overgrazing. For this, cactus cladodes should be harvested and cut into small pieces. These pieces should be mixed with some dry fodder like wheat, paddy straw in 1: 3 ratio (up to 35% of feed). Generally, cacti are highly palatable and digestible. The *in vitro* digestibility values were 72% for protein, 62% for dry matter, 43% for crude fibre and 67% for organic matter.

Nutrient composition: Among the studied accessions at RRS, CAZRI, Kukma, Bhuj, the crude protein content ranged from 4.22 to 11.88%, crude fibre from 12 to 19% and total ash from 15.65 to 26.15%. In general, cactus cladodes are high in moisture (85 to 90%), soluble carbohydrates, Ca and ash and low in

dry matter, crude protein, and crude fibre (Table 2). The forage quality is reported quite comparable with several other cultivated nutritious forages. It is a highly digestible source of energy with about 70% dry matter digestibility but normally low in fibre and protein content. Hence, it should be mixed with some dry fibrous feedstuff (hay or cereal straw) and nitrogenous feed stuff like legume straw (lentil, gram, groundnut straw etc.). Additionally, to increase the nutrient value of cactus feed, small fruits of cactus can be mixed with fodder which will increase fodder quality.

Training and dissemination of cactus pear: A number of field days on thornless cactus were organized at Regional Research Station, Central Arid Zone Research Institute, Bhuj. These programmes were attended by hundreds of farmers from different villages of Kachchh district. Farmers showed a keen interest in the plantation of cactus pear for its fodder and fruit purposes. Large area field demonstration of cactus on 15 farmers' fields were organized in Kachchh districts which revealed the greater scope of cactus as a fodder crop in the region.

SUMMARY

Cactus pear showed great potential for increasing green fodder production in average rainfall years, and to provide a critical reserve of forage for animals in severe drought years. In droughts, cactus can also provide a source of green forage and a much-appreciated source of water for livestock. The study on evaluation of cactus in the drylands of western India revealed the high potential for growing cactus as a fodder crop. However, to capitalize the fullest potential of cactus as a fodder crop, systematic field evaluation for developing location specific production technology and feeding trials on cattle, buffalo and small ruminants are essential.

Table 3. Chemical composition (in percentage) of various feed ingredients

Parameter	<i>Cenchrus ciliaris</i> grass	Pelleted concentrate mixture	<i>Opuntia ficus-indica</i> (cladode)
Dry Matter	95.38	91.87	8.42
Organic Matter	93	84	76
Crude Protein	4.44	23.78	7.88
Crude Fiber	34.5	5.5	10.01
Ether Extract	5.0	7.75	7.75
Nitrogen Free Extract	48.06	46.97	53.36
Total ash	7	16	24
Calcium	0.3	1.04	3.7

(Mathure et al., 2009)

^{1,3}Scientist, ²Head, RRS, CAZRI (Bhuj), ⁴Director, CAZRI, Jodhpur. Corresponding authors' e mail: rahul2iari@gmail.com