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Vitthal K Kauthale
BAIF Development Research Foundation, Central Research Station, Urulikanchan, Pune, Maharashtra, India

Kunal K Punde
BAIF Development Research Foundation, Central Research Station, Urulikanchan, Pune, Maharashtra, India

Corresponding Author:
Vitthal K Kauthale
BAIF Development Research Foundation, Central Research Station, Urulikanchan, Pune, Maharashtra, India

Assessment of spineless cactus (*Opuntia ficus indica*) accessions for growth and yield performance in Western Maharashtra

Vitthal K Kauthale and Kunal K Punde

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Abstract
Cactus pear (*Opuntia ficus indica*) is a xerophytes species widely cultivated in arid and semi-arid regions globally. It is tolerant to drought, high temperature and frost and has multipurpose uses as food, fodder, fuel, fertilizer and bio leather along with industrial importance for value added products. A field experiment was undertaken at BAIF Development Research Foundation, Pune to study the growth and yield performance of various spineless cactus accessions during 2020-23. Fifteen cactus accessions were planted in sandy clay loam soil at a spacing of 2 x 1 m during March 2020. The plant growth parameters, biomass yield and nutritional analysis were recorded at 12, 24 and 36 months after plantation. The study revealed that fresh biomass yield was ranged from 4.18 to 18.81 t ha^{-1}, 17.98 to 97.83 t ha^{-1} and 45.50 to 139 t ha^{-1} during 12, 24 and 36 months after planting. The highest fresh biomass yield of 18.81 t ha^{-1} was recorded in accession Mora Da at first harvest, Yellow San Cono (97.83 t ha^{-1} and 139 t ha^{-1}) at second and third harvest respectively. The plant height was ranged from 139.20 to 198.60 cm, cladodes per plant from 9 to 41, cladode length from 27.20 to 42.30 cm, cladode width from 12.80 to 18.50 cm and cladode thickness from 1.12 to 2.08 cm. The nutritional analysis shown dry matter in the range of 6.56 to 14.44 per cent, crude protein from 5.36 to 8.44 per cent, NDF from 41.35 to 47.23 per cent, ADF from 30.14 to 34.19 per cent and ash from 12.34 to 24.54 per cent. Among the studied accessions, Yellow San Cono recorded better growth performance, biomass yield and protein content followed by Trunzara Red Bronte and Seedless Rocca Plumba which can be promoted for cultivation under Western Maharashtra conditions as a potential source of green fodder for livestock as well as other multiple use.

Keywords: Cactus accessions, fresh biomass yield, growth parameters, nutritional parameters

Introduction
The Cactaceae family comprises approximately 130 genera and 1500 species. Of these, *Opuntia* and *Nopalea* are considered the most important genera because of their significant utility to humans. (Khalafalla *et al*., 2007) [4]. *Opuntia ficus-indica* is one of the most agronomically important species, valued for its edible fruits and cladodes which serve as a vegetable and an important forage source in arid and semiarid areas during drought. (Scheinvar, 1995; Le Houérou, 2000; Juárez and Passera, 2002) [7, 5, 3]. Globally, cactus crops particularly cactus pear (*Opuntia ficus-indica* (L.) Mill.) are receiving increasing attention due to their unique traits and strong resilience to harsh ecological conditions. Cactus pear can be grown on land where no other crops are able to grow; it can be used to restore degraded land (Kamlesh Kumar *et al*. 2018) Cactus is a long-domesticated crop that has emerged as one of the most suitable crop species for arid and semi-arid climate not only for its better Water use Efficiency (WUE) and Rain Use Efficiency (RUE) but also a source to meet the requirements of food, forage and host of other benefits along with ecological advantages (De Kock, 2001) [1] Consequently, this crop has become an essential component of the agricultural economy, especially in arid and semi-arid regions across the world. *Opuntia* represents the best choice since it shows great adaptability to various soil conditions; prevent environmental destruction caused by erosion. *Opuntia* uses 267 kg of water per kg dry matter produced (De Kock, 2001) [1]. This physiological advantage enables the plant to survive and grow well in hot environments. The dry matter content of

Opuntia is less than 15%, indicating its high moisture content. It has low protein content about 4%, low phosphorus and fibre content about 10.0% of the dry matter. However, it is rich in energy, calcium and ash. A study was undertaken to assess the growth and yield performance of fifteen cactus accessions at BAIF, Pune.

Materials and Methods

Cladodes of fifteen spineless cactus accessions were obtained from the Indian Grassland and Forage Research Institute, Jhansi through International Centre for Agricultural Research in Dry Areas in January 2020. These cladodes were kept for curing under room temperature for 10 days to reduce moisture content and then planted in a nursery polybag (9 X 11 inches) consisting of media soil, sand and FYM in proportion of 40:40:20. The protective irrigation was given at the interval of 10 days @ 1 L plant^{-1}. The rooting and sprouting were noticed at 40-45 days after plantation.

The field experiment was conducted at BAIF Development Research Foundation, Urulikanchan Pune, India in sandy loam clay soil having very low level of nutrients. The raised beds of 60 cm width and 30 cm height were prepared for planting the cactus. A basal fertilizer dose of 60:30:30 NPK kg ha^{-1} and FYM @ 10 t ha^{-1} was applied and three rooted cladodes of each accession were planted in the field at a spacing of 2 x 1 m. The protective irrigation of 2 L plant^{-1} at 15 days interval was applied during growth of the plants. Periodical growth observations on plant height, number of cladodes, cladode length, width and thickness were recorded. The plant biomass yield was recorded at 12, 24 and 36 months from the date of plantation in the field. The collected data was statistically analysed and tabulated.

Results and Discussion

Growth performance of various cactus accessions

The data on parameters are depicted in table 1. The significant differences in plant height were observed among the accessions and maximum plant height of 96.75 cm was noticed in accession Trunzara Red Bronte during 12 months. Whereas plant height of 154.25 cm and 195.05 cm was recorded in accession Yellow San Cono at 24 and 36 months of growth respectively.

The highest number of cladodes per plant was observed in accession Yellow San Cono which were 31.50 and 39.50 at 24 and 36 months. Shamsudheen *et al.* reported that different accessions of cactus pear produced 2 to 21 cladodes per plant. The length, width and thickness of matured cladode were significantly influenced due to type of accessions. Accession Yellow San Cono has recorded maximum cladode length of 36.15 cm during first year, whereas accession Blue Molto shown highest cladode length (43.05 and 41.75 cm) during 24 and 36 months followed by in accession Yellow San Cono 38.05 and 38.35 cm at 24 and 36 months respectively. The highest cladode width was noticed in accession Mora Da (16.60 cm) during 12 months and 17.45 cm and 17.60 cm in accession Yellow San Cono and Yellow Santa Margarita Bellica at 24 and 36 months respectively. Sunil Kumar *et al.* (2022) [9] reported highest primary and secondary cladode width (23.33 cm) in Yellow San Cono at the age of 72 months of plantation. The cladode thickness of 1.90 cm was observed in accession White San Cono 14 at 12 months age, whereas 1.91cm and 2.05 cm cladode thickness was recorded in accession Yellow San Cono at 24 and 36 months.

Performance of various accessions for biomass yield

The biomass yield data summarized in Table 1 differed with the type of accession at 12, 24 and 36 months from the planting. The highest biomass yield of 3.72, 19.57 and 26.05 kg plant^{-1} was recorded in accession Yellow San Cono followed by accession Trunzara Red Bronte (3.69, 13.16 and 19.35 kg plant^{-1} at 12, 24 and 36 months after planting respectively. Sunil Kumar *et al* (2022) [9] observed the mean yield in the range of 15.3 to 48 kg plant^{-1} year^{-1} and the highest was in Yellow San Cono (48 kg plant^{-1} year^{-1}) at six years after plantation and also observed a positive correlation between above ground traits and plant biomass. Biomass yield of 13.12 and 18.80 kg plant^{-1} was recorded in accession Seedless Rocca Palumba at 24 and 36 months after plantation. Shamsudheen *et al.* (2017) reported biomass yield of 0.17 to 3.48 kg plant^{-1} after one year of plant growth.

Nutritional evaluation of various accessions

The nutritional evaluation data is presented in Table 2. The data indicated range of dry matter content (6.56 to 14.44 per cent), crude protein (5.36 to 8.44 per cent), Crude fibre (9.06 to 17.61 percent), Ash (12.34 to 24.54 percent), NDF (41.35 to 47.23 per cent), ADF (30.14 to 34.19 per cent) and Silica (0.13 to 0.61 per cent). Sunil Kumar *et al* (2022) [9] reported Dry matter, crude protein, NDF and ADF in the range of 2.9 to 6.9%, 9.0–13.8%, 31.3 to 40.9% and 17.2 to 23.1% respectively. Roy *et al.* (2014) reported dry matter and crude protein in the range of 7.78 to 10.80% and 5.80 to 9.26% in the various accessions of *Opuntia ficus indica.*

Table 1: Growth Performance and Biomass Yield of various accessions

#	Accessions	Plant height (cm)			No. of cladodes plant^{-1}			Cladode length (cm)			Cladode width (cm)			Cladode thickness (cm)			Biomass yield (Kg plant^{-1})		
		12 months	24 months	36 months	12 months	24 months	36 months	12 months	24 months	36 months	12 months	24 months	36 months	12 months	24 months	36 months	12 months	24 months	36 months
1	Yellow San Cono	73.45	154.25	195.05	5.50	31.50	39.50	36.15	38.05	38.35	15.60	17.45	17.15	1.13	1.91	2.05	3.72	19.57	26.05
2	Red San Cono	76.10	131.80	180.10	3.00	27.50	38.00	34.10	34.00	32.35	13.95	15.00	16.50	1.21	1.01	1.47	2.63	10.52	14.80
3	Blue Molto	93.75	114.50	151.95	4.50	7.00	11.00	25.85	43.05	41.75	9.00	13.70	14.35	1.23	0.94	1.34	1.48	3.60	11.15
4	Trunzara Red Bronte	96.75	146.25	187.35	6.00	26.00	34.50	32.75	34.45	35.05	12.00	13.65	14.90	1.37	1.81	1.82	3.69	13.16	19.35
5	White San Cono 16	81.90	148.95	188.95	4.00	18.50	29.00	29.00	33.25	34.25	13.05	14.20	15.45	1.55	1.59	1.72	1.94	8.89	14.15
6	Yellow Santa Marghorita Belica	86.50	130.55	173.85	4.50	26.00	33.50	27.80	34.35	34.15	14.20	15.90	17.60	1.40	1.42	1.49	2.02	11.37	14.00
7	Algerian	72.45	130.90	169.65	3.00	26.00	22.50	26.60	34.30	35.10	15.35	16.15	15.35	1.72	1.38	1.47	2.37	12.64	15.70
8	Seedless Rocca Palumba	65.90	133.60	171.85	4.50	28.50	36.50	27.30	32.90	33.80	15.65	16.75	16.30	1.60	1.45	1.44	2.63	13.12	18.80
9	Rolly Polly	73.05	130.25	179.55	2.50	11.50	18.00	21.30	31.25	31.00	8.55	14.95	15.15	1.07	1.41	1.66	0.88	5.43	11.50
10	Red Rocca Plumba	96.70	135.80	166.85	4.50	9.50	11.50	29.15	29.15	30.85	10.95	13.95	15.00	1.42	1.52	1.71	2.24	6.11	12.64
11	White San Cono 14	75.25	136.90	174.95	4.00	14.50	19.50	26.00	32.45	32.95	13.80	15.65	15.85	1.90	1.38	1.43	1.99	7.20	13.50
12	Mora Da	82.65	142.95	182.15	7.00	15.00	19.00	32.70	33.00	32.45	16.60	15.55	16.45	1.06	1.31	1.32	3.76	5.94	15.70
13	Yellow Rocca Plumba	77.95	114.00	143.70	2.50	15.00	19.50	32.20	34.00	34.90	11.45	16.80	16.55	1.56	1.48	1.46	1.21	8.58	15.30
14	White Rocca Palumba	65.45	130.00	148.35	2.50	14.00	17.50	25.10	34.50	35.85	11.00	16.70	16.65	1.13	1.70	1.74	0.94	6.90	12.76
15	Zastron	79.25	114.85	154.90	2.50	10.50	13.50	30.25	26.05	28.40	9.10	13.20	14.10	1.50	1.90	1.99	0.84	4.81	10.05
	Mean	79.81	133.04	171.28	4.03	18.73	24.20	29.08	33.65	34.08	12.68	15.31	15.82	1.39	1.48	1.61	2.15	9.19	15.03
	SE±	2.58	3.14	4.01	0.36	2.08	2.58	1.02	0.97	0.82	0.68	0.35	0.26	0.07	0.07	0.06	0.26	1.09	1.03

Table 2: Nutritional evaluation of various cactus accessions

#	Accession Name	Dry Matter%	Crude Protein%	Crude Fibre%	Ether extract%	Ash%	Silica%	NDF%	ADF%
1	Yellow San Cono	7.60	8.44	16.82	1.02	23.91	0.35	47.23	31.01
2	Red San Cono	9.81	5.46	12.34	1.11	18.28	0.61	46.25	32.44
3	Blue Molto	9.20	6.94	15.00	1.14	20.89	0.15	47.01	31.28
4	Trunzara Red Bronte	10.54	5.83	14.23	1.30	22.29	0.49	44.32	32.30
5	White San Cono 16	8.36	8.39	15.28	1.24	23.15	0.25	45.15	31.22
6	Yellow Santa Marghorita Belica	11.01	6.41	12.28	1.20	16.2	0.13	45.26	31.52
7	Algerian	7.01	7.40	12.81	1.14	24.54	0.39	41.35	32.01
8	Seedless Rocca Plumba	9.39	6.95	11.13	1.16	21.76	0.14	44.36	30.14
9	Rolly Polly	9.66	6.89	17.61	1.21	19.65	0.19	45.24	30.26
10	Red Rocca Plumba	6.56	8.17	9.88	1.04	22.83	0.17	46.18	31.22
11	White San Cono 14	7.57	6.22	9.90	1.13	21.45	0.22	47.22	31.43
12	Mora Da	14.44	7.57	9.06	1.04	13.41	0.16	43.65	34.19
13	Yellow Rocca Plumba	7.30	6.01	10.04	1.14	14.26	0.14	44.17	33.24
14	White Rocca Palumba	9.16	5.91	9.97	1.17	12.34	0.26	44.26	31.25
15	Zastron	11.26	5.36	10.13	1.34	13.14	0.27	46.21	30.28

Conclusion

It could be concluded from the results of the study that among the fifteen cactus accessions, Yellow San Cono recorded better growth performance, biomass yield and protein content followed by accession Trunzara Red Bronte and Seedless Rocca Palumba. The better performing accessions can be promoted for cultivation under Maharashtra conditions as a potential source of green fodder for livestock as well as for other multiple uses.

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