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Germplasm Collection, Characterization and Propagation of *Cordia gharaf* Forsk.: An Underutilized Multipurpose Tree for Agroforestry in Hot Arid Region

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ABSTRACT

Cordia gharaf Forsk, (Syn. *C. rothii*, *C. sinensis*) also known as 'Goondi', is a multipurpose woody perennial species found in hot arid zones. It is well-adapted to soil moisture stress, desiccated winds, and high ambient temperatures. Its ripe fruits are eaten fresh and dried for future consumption, and it is traditionally used as herbal medicine and fodder for browse material. Twelve collections were made across Jaisalmer district, covering diverse habitats. The species generally flowers during March-April and fruiting occurs in May-June. The ripe fruits have a round to ovoid shape and an orange to reddish brown color. Fruit/seed characters were studied at a laboratory and seedlings were raised in polybags for germination and growth study at a nursery in Jaisalmer in 2015. The Badabagh collection (CAZJCG-1) and Dangri (CAZJCG-7) collections showed maximum (46%) and minimum (17%) seed germination, respectively. The morpho-metric parameters of the seedlings were also studied, with the Badabagh collection recording the highest shoot length (87.18 cm), collar diameter (8.68 mm), and shoot dry weight (38.36 g) after 120 days of seed sowing. The Badabagh collection also showed high seedling vigour indices. The study revealed that Badabagh collection (CAZJCG-1) performed better with respect to seed germination and seedling growth parameters.

Keywords: *Cordia gharaf,* Goondi, underutilized, hot arid, agroforestry, germplasm, seedling evaluation

The challenge to sustain agricultural production at a desired growth rate is extremely difficult in arid zone, which are bestowed with severe edapho-climatic variability *viz.*, low and erratic rainfall, high temperature due to intense solar radiation, high evapotranspiration, strong wind, undulating lands, soil erosion and sandy soil with marginal to poor fertility. In such a harsh situation, cultivation of arable crops as only land use activity is extremely risky and highly uneconomical. Therefore, alternate land use technologies and management are indispensable to sustain livelihood through rainfed agriculture.

Agroforestry has not only the great potential in conserving of natural resources in the fragile

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ecosystem but also provides livelihood security against nature's calamities. This essentially involves a perennial component either tree or shrub, and provide cover to the soil, which contribute to the conservation of soil and water resources in the arid zone. It improves soil quality through increased soil organic matter addition from litter fall and root turn over; reduce surface evaporation and weed growth and improves water use efficiency through differential utilization of soil moisture stored in various soil layers. Apart from that, it also provides good quality green fodder, fuel wood, timber and minor forest products and lessens the farmers' dependence on forest reserves. The fruit and fodder from the hardy trees serves as an insurance against food and fodder security in draught and famines. The traditional agroforestry systems include silvipasture, agrisilvipasture, agrihorticulture and hortipasture with limited species. In order to augment the production and income from rainfed areas besides bringing the required stability, intervention is needed through exploiting untapped potential of region specific trees/shrubs for agroforestry, which are draught resistant, having deep root system, can be cultivated with minimum organic inputs and quality of produce is better under stress condition.

Cordia gharaf Forsk. is such an under-utilized important multipurpose small tree of hot arid region of Western Rajasthan, which is commonly known as Goondi and belongs to the family Boraginaceae. It is well adapted to soil moisture stress, desiccated winds and high ambient temperature due to morphological and physiological adaptability. It has great potential to withstand biotic pressure, reduce soil erosion, improve soil productivity and thereby providing livelihood security against nature's calamities *viz.*, drought and famine (Singh and Kumar, 2005). This multipurpose species is used as food, fodder, fuel wood, medicine and for making agricultural implements (Dagar *et al.* 2001). It is often cultivated for its edible fruit. The fully ripen fruits are bright orange coloured and often found to be sold in local markets of Western Rajastnan (Rathore, 2009). The fodder provided by this tree is highly preferred by desert dwelling browsing animals like sheep and goats (Balehegn *et al.* 2015). Despite its paramount importance, less research attention has been paid to utilize this valuable woody perennial under alternate land use system. Along with other valuable products, this species has immense capacity to provide flushes of leaf fodder under dry conditions. Therefore, the present study was undertaken to collect and identify the elite germplasm of *C. gharaf* to assess its growth potential for eventual utilization under agroforestry system in the hot arid zones of Western Rajasthan.

MATERIALS AND METHODS

Field survey, germplasm and passport data collection

Field surveys were conducted in Jaisalmer district of Rajasthan for collection of *C. gharaf* germplasm in two consecutive years (2016 and 2017) during the fruiting stage in the months of June to August. Twelve germplams of *C. gharaf* were collected from diverse habitats viz., farmer's field / field bunds, wasteland and rangeland areas. The passport information of location details was also collected during field surveys. Germplasm in the form of fruits were collected from different sites including protected farmer fields and unprotected rangelands. The primary information on the ethno-botanical uses was also collected from the local inhabitant using a house hold survey, semi-structured questionnaire and interviews of the elder people of the family. The initial characterization was carried out for fruits and seeds traits like fruit size, seed size, 100 seed weight and juice recovery.

Experimental site

The experiment was carried out in the nursery at ICAR-Central Arid Zone Research Institute (CAZRI), Regional Research Station, Jaisalmer, Rajasthan, India, located at latitude 26.996 °N, longitude 71.334 °E and altitude 216 m during 2016-17. The study site is characterized by low rainfall (276 mm year^{-1}), high maximum temperature (46°C) during summer. The soil at the experimental site was sandy having pH 8.9 and EC 0.16 ds/m. The organic carbon, available N_2, P_2O_5 and K_2O were 0.12%, 0.010%, 40 Kg/ha, 230 kg/ha, respectively at the study site.

Experimental details

The experiment was conducted using complete randomized design (CRD) in nursery at ICAR-Central Arid Zone Research Institute, Regional

Research Station, Jaisalmer, Rajasthan, with three replication and nine treatments. The accession was taken as the treatments, constituting nine treatment replicated thrice. Seeds of collected germplasm were sown in poly-bags prepared with soil mixture of sand, silt and FYM (1:1:1). The observations like germination percentage, plant survival percentage, seedling height, collar diameter, number of branches, root length, root: shoot ratio, seedling vigour index were recorded. The data so obtained were analyzed using MS Excel.

RESULTS AND DISCUSSION

Collection, distribution and diversity

The passport information viz., place of collection, habitat type, morphometric form and geographical co-ordinates for each collected germplasm are presented in Table 1 and Fig 1. Nine germplasm were from farmers' field and managed habitat, while three of them were from rangeland and unmanaged condition. During the field survey,

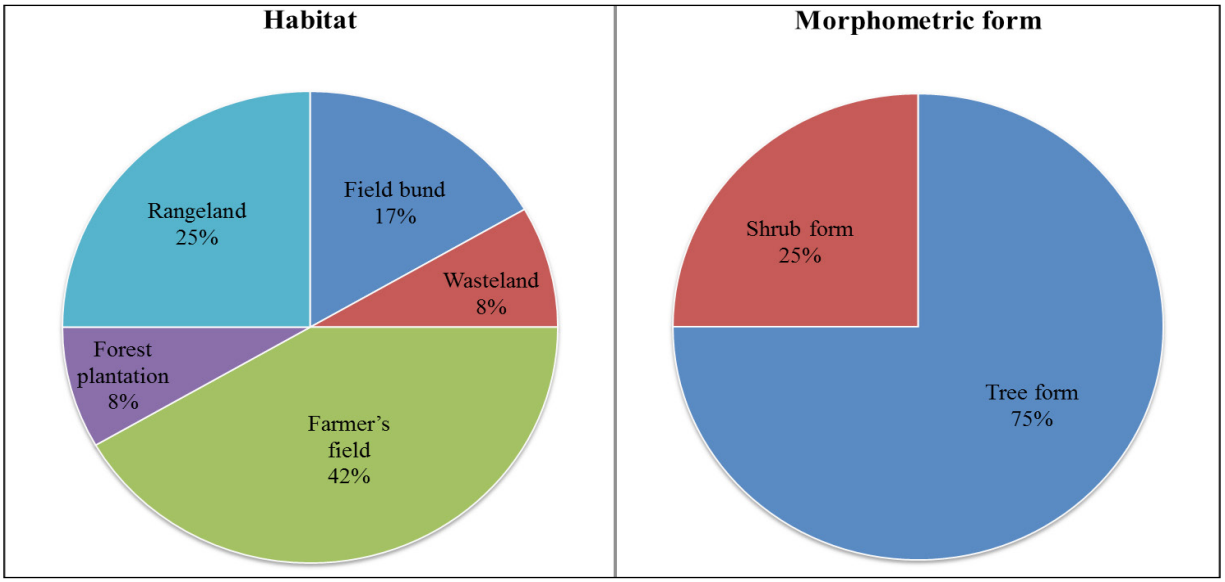

Fig. 1: Habitat and morphometric diversity of collected germplasm of *C. gharaf*

Table 1: Passport information of collected germplasm of *Cordia gharaf*

Sl. No.	Accession name	Place of collection	Habitat	Latitude	Form	Longitude	Altitude (feet)
1	CAZJCG1	Badabagh	Field bund	26.9601	Tree	70.8851	719
2	CAZJCG2	Badabagh	Field bund	26.9606	Tree	70.8849	716
3	CAZJCG3	Badabagh	Wasteland	26.9555	Tree	70.8856	782
4	CAZJCG4	Barhamsar	Farmer's field	26.0163	Tree	70.8614	566
5	CAZJCG5	Amarsagar	Farmer's field	26.9320	Tree	70.8697	835
6	CAZJCG6	Jairat	Forest plantation	26.8661	Tree	71.0938	723
7	CAZJCG7	Dangri	Farmer's field	26.5265	Tree	71.3265	937
8	CAZJCG8	Dangri	Farmer's field	26.5269	Tree	71.3264	935
9	CAZJCG9	Sariya	Farmer's field	26.8837	Tree	70.9856	811
10	CAZJCG10	Mehrari	Rangeland	26.4921	Shrub	71.3951	974
11	CAZJCG11	Mehrari	Rangeland	26.5195	Shrub	71.3812	968
12	CAZJCG12	Thaiyat	Rangeland	26.9340	Shrub	71.0231	747

distinct morphological and phenological variation was observed within the species among different habitats. The species found to exhibit both tree as well as shrub form depending upon the habitat type and management condition. It exhibited tree form mostly in protected arable area/plantation and flowered during March-April and fruiting in May-June, however it showed shrub form in unprotected rangelands, where flowering/fruiting occur after monsoon rains in July-August.

Earlier studies have reported wide genetic diversity in natural populations of *C. gharaf* with respect to plant height, flowering (time and colour), fruiting (time and colour), and growth habits of plants from the inland region to the coastal region of Gujarat (Dev *et al.* 2020). It has been viewd as an under unexplored jewels of Thar desert (Karakilcik, 2014) and given the status "Vulnerable" species of Thar desert (Syed Sadruddin Hussain, 2010). Aregu and Demeke (2006) also stated *C. gharaf* as threatened species in Arba-Minch Riverine forest and woodland of Ethiopia and stressed on its conservation measures. This is a very hardy species which can survive well in gravely areas even under saline and alkaline conditions and is highly salt tolerant species, even at seedling stage (Ramoliya and Pandey, 2002). This species has a tendency for rapid root penetration and roots are able to extract water from even very dry saline soil (6.8% moisture). Dagar *et al.* (2001) also found that *C. gharaf* showed 70% survival on highly alkali soil (pH>10). Its long tap root system and appropriate adaptive mechanism allow the plant to survive in semiarid, arid, and rainfed habitats. (Meghwal *et al*. 2014).

Fruit and seed characterization

Fruit and seed characterization of collected germplasm was done to know the spatial variation of fruits in different geographical locations. Length of fruit varied between 9.63 to 11.84 mm and the value of fruit diameter ranged 9.13 to 10.71. Juice recovery of the fruits had a value 23.41 to 37.38 (Table 2). The data showed that CAZJCG1, CAZJCG2 (in field bund) CAZJCG3 (in waste land) and CAZJCG6 (in forest) had lower juice recovery. This indicates that plants left unattended yielded less juice as comparison to germplasm grown in farmer's field. The value of seed length and breadth varied between 7.35 to 8.41 mm and 4.31 to 4.92, respectively. The forms of plant and its fruits and seeds are presented in Fig. 2.

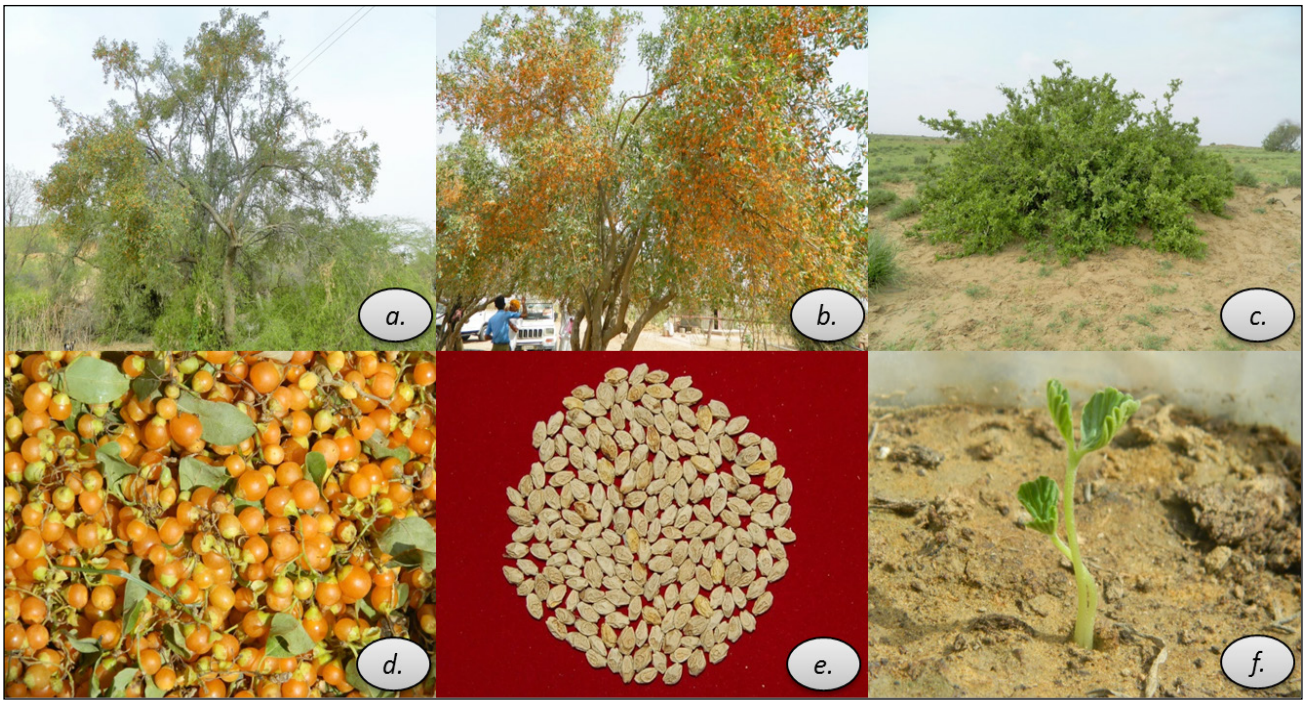

Fig. 2: *Cordia gharaf* (Goondi) **(a)** tree form **(b)** fruiting stage **(c)** shrub form **(d)** fruits **(e)** seeds and **(f)** germinating seedling

Table 2: Fruit and Seed parameters of collected germplasm of *Cordia gharaf*

Sl. No	Accession	Fruit length (mm)	Fruit dia (mm)	Juice recovery (%)	Seed length (mm)	Seed breadth (mm)	100 Seed wt. (g)
1	CAZJCG1	11.72	10.58	23.41	8.23	4.76	7.14
2	CAZJCG2	11.84	10.37	29.53	8.41	4.71	6.96
3	CAZJCG3	11.51	10.71	24.57	8.07	4.92	7.33
4	CAZJCG4	10.87	9.87	30.54	7.9	4.68	6.67
5	CAZJCG5	9.81	9.13	37.38	7.35	4.28	5.77
6	CAZJCG6	11.27	10.22	27.49	8.12	4.81	7.02
7	CAZJCG7	10.53	10.21	31.38	8.01	4.70	6.81
8	CAZJCG8	10.26	9.21	32.47	7.53	4.58	6.28
9	CAZJCG9	9.74	9.86	31.63	7.84	4.69	6.44
10	CAZJCG10	9.63	9.45	34.72	7.36	4.31	5.94
11	CAZJCG11	9.92	9.24	32.44	7.51	4.57	6.17

Seed germination study

Nursery was prepared and seeds were sown in polybags. Germination started after four days of sowing and 50% germination completed within nine days. Maximum seed germination (46%) was recorded in Badabagh collection. However, collection from rangeland areas (CAZJCG10, CAZJCG11 and CAZJCG12) showed very poor germination. Fig. 3 depicted the 30 days old seedlings raised in the nursery which revealed distinct growth variation.

The results are supported by Dev *et al.* (2020), who also reported low seed germination (28–42%) of the species. Meghwal (2007) also substantiate the findings who reported the seed as the standard propagation method of *Cordia species*, including *C. gharaf*, and noted maximum seed germination upto 50–60%.

Seedling growth parameters

Morphometric parameters of the seedlings *viz.*, shoot length, collar diameter, root length, root shoot ratio and number of branches were recorded. Variations observed among different germplasm with respect to seed germination and seedling growth parameters under nursery condition (Table 3). After 120 days of planting, maximum shoot length (87.18 cm), collar diameter (8.68 mm) and shoot dry matter (38.36 g) was recorded in the seedlings raised from Badabagh collection (CAZJCG1). Higher root length observed in Badabagh collection makes it well adapted to the harsh climate having greater access to water and nutrient. The germplasm collected from Dangri (CAZJCG1) had least germination percentage and other seedling parameters were also least in this particular germplasm.

In order to check consistency in seedling growth parameters, shoot length and collar diameter were compared at an interval of 30 and 120 days after sowing (DAS) as represented in Fig. 4. The results of the experiment revealed that among the 12 germplasm, Badabagh collection (CAZJCG1) performed better with respect to seed germination and seedling growth parameters under nursery condition.

Ethno-botanical importance and traditional utilization

The ethno-botanical information were collected from the local inhabitant revealed that this under-utilized shrub are used as food, fodder, fuel, Pharmaceutical and Ecological and environmental role.

Food: The species is often cultivated for its edible fruits. During summer season (May- June), the tree is bestowed numerous orange colored ripe fruits which are attractive, sweet and delicious. Ripe fruits are sold in local market. Seeds are also eaten along with fruits. Rathore, (2009) also reported selling of its ripen fruits in the local markets of arid Rajasthan. In addition to being eaten raw, the sticky, sweet pulps were occasionally added to porridge in place of sugar.

Table 3: Variation in seed germination and seedling growth parameters of nine different germplasm of *Cordia gharaf* under nursery condition

Sl. No.	Accession	Germn. (%)	30 days after sowing						120 days after sowing			
			Shoot length (cm)	Collar Dia. (mm)	Root length (cm)	Shoot dry wt. (g)	Root dry wt. (g)	R : S (DW) Ratio	Shoot length (cm)	Collar Dia. (mm)	Mean No. of branches	Shoot dry wt. (g)
1	CAZJCG1	46	23.38	3.62	31.8	1.76	0.81	0.46	87.18	8.68	17.43	38.36
2	CAZJCG2	39	19.07	3.41	27.2	1.54	0.66	0.43	72.09	7.52	14.11	34.24
3	CAZJCG3	36	18.67	3.28	28.3	1.43	0.63	0.44	62.08	6.46	15.21	31.83
4	CAZJCG4	35	18.28	3.28	22.5	1.32	0.54	0.41	56.85	6.55	13.35	27.14
5	CAZJCG5	25	14.60	3.03	16.2	0.87	0.33	0.38	57.27	6.75	11.55	29.63
6	CAZJCG6	27	17.38	3.22	19.8	1.23	0.51	0.41	58.06	6.72	10.23	31.33
7	CAZJCG7	17	15.29	3.15	16.4	0.94	0.34	0.36	56.44	6.20	9.38	26.76
8	CAZJCG8	18	17.25	3.29	20.1	1.11	0.43	0.39	58.31	6.64	12.54	29.24
9	CAZJCG9	21	16.78	3.36	18.9	1.06	0.40	0.38	60.77	6.68	10.19	30.68

Fig. 3: Seedlings in the nursery at 30 days after sowing

Fodder: The species receive highly *in-situ* browsing pressure by goats and sheep. They even destroy the low lying branches for its leaf fodder. Balehegn *et al*. (2015) worked on local valuation of indigenous fodder trees and shrubs used by pastoral and agrarian communities in northern Ethiopia. They found that among top 20 preferred fodder species, *Cordia gharaf* and *Ziziphus spinachristi* were the most locally preferred fodder species by the ethnic/ livelihood groups.

Fuel: The local inhabitant reported that the species provides excellent fuel wood. Nirmal Kumar *et al.* (2011) compared the fuel wood properties of several arid species and found that calorific value of *C. gharaf* (24.21 KJ/g dry wt) is comparable to *Prosopis cineraria* (24.21 KJ/g dry wt).

Pharmaceutical role: The species have great medicinal and pharmacological value. Its bark has astringent properties, the decoction of which is used as a gargle.

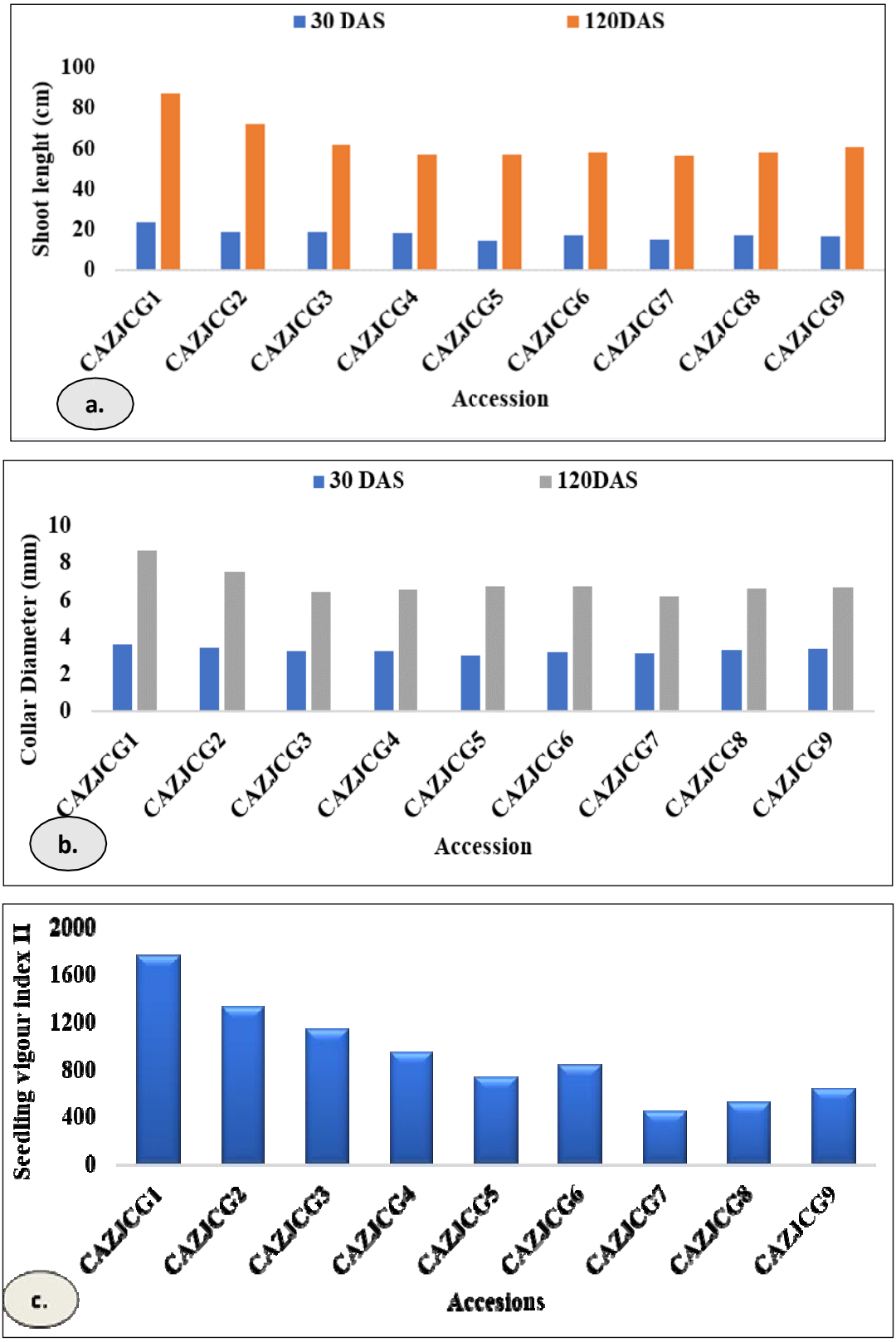

Fig. 4: Comparison of seedling growth parameters among of different germplasm of *Cordiagharaf*- **(a)** Shootlength**(b)** Collar Diameter and **(c)** Seedling vigour

It also used to treat dyspepsia and fever. It is having cardio tonic activity. Useful in constipation, stomach worms, piles and toothache. Leaves extract shows significant increase in the wound-healing activity. The results are supported by Bhandari (1990) who also reported astringent properties of its bark and Chauhan *et al*. (2009) who observed cardiotonic activity in the bark. Ghori *et al*. (2011) reported that its fruits have astringent, demulcent, diuretic, purgative, anti-ulcer and hepatoprotective properties and useful in constipation, stomach worms, piles and toothache. Zala *et al*. (2012) attributed that significant increase in the wound-healing activity in the animals treated with the alcohol and water extracts of its leaves is due to the presence of carbohydrates, glycosides, saponins, steroids, triterpenes, proteins, amino acids and mucilage in the leaf extracts.

Singh and Kumar (2005) highlighted to exploit its potential in the hot arid zones of Western Rajasthan particularly in Jaisalmer, Barmer and Bikaner districts. However, more research interventions are needed to explore the untapped potential of C. *gharaf* to be utilized as an agroforestry species in the farmer's field on a wider scale.

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