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Identification and Characterization of White Seeded Sponge Gourd (*Luffa cylindrica* Roem.) Genotype under Hot-arid Region

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ABSTRACT

The field experiment was conducted during *kharif* (July–November, 2022; July–November, 2023) and *Spring-Summer* (February–May, 2022 and February–May, 2023) seasons at research farm of ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner, Rajasthan, India to evaluate and characterize the sponge gourd genotypes to identify trait-specific genotypes. Sixteen sponge gourd genotypes were assessed for morphological performance and some qualitative traits. Substantial variations for days to 50% female flowering, days to first harvest, fruit length, fruit weight and fruit yield plant^{-1}, were recorded. Days to 50% female flowering and days to first harvest were varied as 38.33–67.67 and 46.33–67.67, respectively. Similarly, fruit length, fruit weight and fruit yield plant^{-1} were ranged in 13.04–28.43 cm, 73.78–116.78 and 0.67–2.82 kg, respectively. The results of clustering indicated that all genotypes were separating in four groups. This collection of sponge gourds would be useful for the gene pools and a wide range of phenotypic variations to provide a good source of diversity for developing of sponge gourd cultivars in breeding programs. Ovate, reniform and orbicular leaf shapes; light green, medium green, dark green and green with stripes fruit skin colours; elliptical, elongate slim, elliptical elongate fruit shapes were observed among the genotypes. Genotype AHSG-23 was having the white coloured seeds at maturity while all the genotypes were having black colour seeds. This trait was stable as studied in four different environments. Therefore, white seeded AHSG-23 might be utilized as a trait-specific genotypes and the trait would be morphological marker in breeding programmes.

KEYWORDS: Morphological marker, *Luffa cylindrica*, trait-specific, white seeded

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1. INTRODUCTION

Vegetable crops, especially the cucurbits (gourds, melons, squashes and pumpkins), are rich in nutrients. Sponge gourd is one of the important cucurbitaceous vegetables. It is a popular in the tropics and is essentially an old-world species. Its immature fruits are used as vegetables and mature fruits as fibres for making bath sponge and washing utensils also. It is grown in Asia and Africa, and widely used as a vegetable in India, China and other Asian countries. The genus *Luffa* consists of ten species: *Luffa aegyptiaca* Mill., *Luffa acutangula* Roxb., *Luffa graveolens* Roxb., *Luffa echinata* Roxb., *Luffa umbellata* M. Roem., *Luffa tuberosa* Roxb., *Luffa quinquefida* (Hook. and Arn.) Seem., *Luffa astorii* Svens. *Luffa saccata* F.Muell. ex I. Telford. and *Luffa hermofrodita* Singh and Bhandari (Prakash et al., 2014). *Luffa aegyptiaca* Mill. and *Luffa acutangula* Roxb. are economically cultivated species in the world (Chandra, 1995). *Luffa hermaphrodita* is also cultivated species in minor areas of India (Marr et al., 2005, Sidhu and Kaur, 2021, Bhutia et al., 2023). Sponge gourd (*Luffa cylindrica* Roem, 2n=2x=26) is a monoecious and annual cucurbitaceous vegetable, which is a native of the Africa (Porterfield, 1955) and subtropical Asian region, particularly India (Kalloo,1993). It is commonly grown for its tender fruits, natural sponge, and potential medicinal properties (Liu et al., 2010, Sharma et al., 2014, Mashilo et al., 2025). Its fruits are used in the traditional chinese medicine as an anthelmintic, stomachic, antioxidant and antipyretic (Pal and Manoj, 2011). Based on varied utilizations, it is vernacularly known as dishcloth gourd, towel gourd, vegetable sponge, and smooth gourd (Porterfield, 1955, Cho et al., 2015, Gong et al., 2024, Mashilo et al., 2025). Its tender fruits are a rich source of antioxidants, viz., vitamin A and vitamin C, flavonoids, and minerals Mg, K, Fe, Ca, Cu, Zn, Na, and Mn (Yawalkar, 2004, Oboh and Aluyor, 2009). Dried fruits having large volume of fibrous portion are used for body scrubbing, clearing utensils, making shoe-soles, filters, etc (Bal et al., 2004, Altinsik et al., 2010, Kumar and Pandit, 2022). Sponge gourd is cultivated during the spring–summer and rainy seasons in Northern India and throughout the year in Southern India (Islam et al., 2011). Sponge gourd plants are generally having green coloured foliage, yellow flowers which mostly open in forenoon hours, light green to dark green fruits and brown-black seeds at maturity. Plant genetic resources and germplasms are fundamental sources for plant breeding that the assessment of the genetic diversity among genotypes is useful to facilitate more efficient use of plant genetic resources (Harshitha et al., 2019; Kumar and Pandit, 2022; Rai et al., 2025). The development and use of various types of markers in plant genetics and breeding not only facilitated faster scientific progress in fundamental research but also allowed researchers to apply the obtained knowledge in practice (in particular, in the implementation of breeding programs) with the least time and material costs. The main sources of genotypic variability (the basis, reflection, and manifestation of which is polymorphism, including marker polymorphism, manifesting not only at the morphological but also at the biochemical or molecular levels) are mutations and recombinations. Morphological markers are usually visual indicators of phenotypically differing characters, such as colour, shape, and size of the flower, seeds, or leaves; type of development of plants, inflorescences, or root system; pigmentation; or habit. Creation and preservation of identified genetic collections is necessary to increase the efficiency of selection and genetic studies. The present investigation was aimed to evaluate, characterize and assess morphological diversity among sponge gourd genotypes as well as to identify rare/specific traits among the sponge gourd genotypes.

2. MATERIALS AND METHODS

The field experiment was conducted during *kharif* (July–November, 2022; July–November, 2023) and *spring-summer* (February–May, 2022 and February–May, 2023) seasons at research farm of ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner (28°N, 73° 18° E at an altitude of 234.84 m amsl), Rajasthan. The sixteen sponge gourd genotypes were evaluated and characterized under natural field conditions. For rainy season evaluation, the seed material was sown on 01st August during both the years. Similarly, for summer season evaluation, the seed material was sown on 15th February during both the years. Each genotype was sown under drip irrigation system having row to row distance of 180 cm and plant to plant distance of 90 cm. Standard package of practices recommended for sponge gourd cultivation was followed to raise a good crop. During *summer* season, initially the weather was mild to hot but after mid-march, the temperature rose suddenly and it was extremely hot (above 42°C) and dry while during *kharif*, initially with the onset of monsoon, the humidity was 70–90 % for few days but after mid-august, it was also experiencing high temperature (above 35°C) along with aridity because of uncertain and erratic rain pattern of hot arid region. All the individual rows of all the genotypes were observed for important qualitative traits, viz. leaf shape, fruit skin colour, fruit shape and seed colour. Similarly, quantitative traits, viz. days to 50% female flowering, days to first harvest, fruit length, fruit weight and fruit yield plant^{-1} were also recorded. Observations on days to 50% female flowering and days to first harvest were recorded on whole row basis while, rest of the observations were observed on 5 random plants and then averaged. Mean data for each character were evaluated by one-way analysis of variance (ANOVA) followed by Duncan's multiple range test when the P value less than 0.05 was considered significant. Cluster analysis were carried out using the R-studio.

3. RESULTS AND DISCUSSION

3.1. Flowering and fruit harvest traits

Sixteen sponge gourd genotypes were evaluated for both quantitative and qualitative characters. On the perusal of the quantitative traits (Table 1 and 2), the days taken to 50% female flowering ranged from 45.00–67.67, 41.67–63.33, 43.33–65.67 and 38.33–53.00-days during SS 2022, RS 2022, SS 2023 and RS 2023, respectively. Range for the days to first fruit harvest was from 53.00–67.67, 48.33–63.33, 50.00–65.33- and 46.33–62.00-days during SS 2022, RS 2022, SS 2023 and RS 2023, respectively. AHSG-25 has taken minimum days for appearance of 50% female flowering (38.33–45.00 days) and first fruit harvest (46.33–53.00) followed by AHSG-23 (43.33–46.67 days for 50% female flowering; 52.00–54.33 days for first fruit harvest) as studied over four seasons (SS-2022, RS-2022, SS-2023 and RS-2023). Hence, both the genotypes might be considered as earliest genotype among all studied. Kumar and Pandit, 2022 evaluated forty-five sponge gourd genotypes for seventeen growth and yield traits. They reported that days to first male flower appearance ranged from 30.88 to 49.85 while days to first female flowering was in range of 35.23–55.50. Rai et al., 2025 studied mean performance and genetic diversity in thirty-four ridge gourd genotypes and they found significant variability in DMFE-days to first male flower emergence (38.40-49.40), DFFE-days to first female flower emergence (44-13-51.40) and DFFH-days to first fruit harvest (54.13-62.07).

3.2. Yield and its attributing traits

Fruit length was ranged from 13.04–24.59 cm, 16.83–28.43 cm, 13.90–25.48 cm and 16.23–27.73 cm during SS 2022, RS 2022, SS 2023 and RS 2023, respectively. Range for fruit weight was observed from 73.78–107.27 g, 84.49–116.78 g, 77.28–111.22 g, 81.80–114.05 g during SS 2022, RS 2022, SS 2023 and RS 2023, respectively. Further the data for fruit yield plant^{-1} was ranged from 0.67–2.13 kg, 1.38–2.82 kg, 0.71–2.19 kg and 1.32–2.75 kg during SS 2022, RS 2022, SS 2023 and RS 2023, respectively. Genotype, AHSG-23

Table 1: Flowering and fruit harvest traits in sponge gourd genotypes over the environment

Genotypes	Days to 50% female flowering				Days to first fruit harvesting			
	SS 2022	RS 2022	SS 2023	RS 2023	SS 2022	RS 2022	SS 2023	RS 2023
AHSG-16	57.67^{bc}	55.33^{bcd}	56.00^{cde}	51.3^{3ab}	65.33^{a}	61.00^{abc}	63.33^{ab}	60.00^{abc}
AHSG-17	59.00^{bc}	57.00^{abcd}	58.33^{bcd}	52.67^{ab}	60.33^{abcd}	57.33^{abc}	59.00^{bcd}	56.67^{abcde}
AHSG-18	51.00^{cd}	53.00^{cde}	54.33^{de}	51.00^{ab}	62.67^{abc}	63.00^{ab}	65.33^{a}	61.13^{ab}
AHSG-19	58.67^{bc}	56.00^{abcd}	57.33^{bcd}	51.33^{ab}	67.00^{a}	63.33^{a}	64.00^{ab}	62.00^{a}
AHSG-20	55.33^{c}	55.33^{bcd}	53.67^{de}	51.00^{ab}	55.67^{cd}	55.00^{bcd}	56.33^{cde}	53.00^{de}
AHSG-21	56.67^{c}	54.33^{bcd}	55.33^{de}	50.00^{ab}	67.67^{a}	63.33^{a}	64.33^{ab}	62.00^{a}
AHSG-22	54.33^{c}	53.33^{cde}	53.33^{de}	49.00^{ab}	60.00^{abcd}	57.67^{abc}	58.67^{bcd}	55.67^{bcde}
AHSG-23	46.00^{d}	46.67^{ef}	45.00^{f}	43.33^{cd}	54.33^{cd}	53.33^{cd}	54.33^{de}	52.00^{ef}
AHSG-25	45.00^{d}	41.67^{f}	43.33^{f}	38.33^{d}	53.00^{d}	48.33^{d}	50.00^{e}	46.33^{f}
AHSG-27	50.67^{cd}	52.00^{de}	50.00^{ef}	47.67^{bc}	56.67^{bcd}	56.33^{abcd}	57.00^{cd}	55.33^{cde}
AHSG-28	56.33^{c}	54.00^{cde}	55.00^{de}	47.67^{bc}	61.33^{abcd}	57.67^{abc}	59.00^{bcd}	55.00^{cde}
AHSG-29	57.67^{bc}	55.33^{bcd}	57.00^{bcd}	48.33^{ab}	62.00^{abc}	58.00^{abc}	59.67^{abcd}	55.67^{bcde}
AHSG-30	59.33^{bc}	58.33^{abcd}	57.00^{bcd}	52.00^{ab}	61.67^{abcd}	61.00^{abc}	61.67^{abc}	59.33^{abc}
AHSG-31	67.67^{a}	63.33^{a}	65.67^{a}	52.67^{ab}	65.00^{ab}	60.33^{abc}	61.67^{abc}	58.67^{abc}
AHSG-32	65.33^{ab}	60.33^{abc}	62.33^{abc}	51.33^{ab}	62.33^{abc}	58.67^{abc}	58.67^{bcd}	57.67^{abcd}
AHSG-34	67.33^{a}	62.00^{ab}	63.33^{ab}	53.00^{a}	66.00^{a}	61.00^{abc}	63.33^{ab}	59.33^{abc}
CD (*p*=0.05)	7.541	6.669	6.012	4.360	7.388	6.906	5.400	4.923
SEm±	2.598	2.298	2.071	1.502	2.546	2.380	1.861	1.696
SEd±	3.675	3.250	2.929	2.125	3.600	3.365	2.631	2.399
CV	7.930	7.253	6.472	5.266	7.192	7.050	5.391	5.167

RS: Rainy season; SS: Summer season

Table 2: Yield and its attributing traits in sponge gourd genotypes over the environment

Genotypes	Fruit length (cm)				Fruit weight (g)	
	SS 2022	RS 2022	SS 2023	RS 2023	SS 2022	RS 2022
AHSG-16	14.26^{fg}	19.99^{def}	16.45^{def}	17.90^{def}	73.78^{e}	84.49^{g}
AHSG-17	13.04^{g}	17.83^{fg}	14.47^{fg}	16.57^{ef}	85.42^{cde}	93.85^{cdefg}
AHSG-18	15.43^{ef}	18.88^{efg}	15.97^{efg}	18.47^{cdef}	97.66^{abc}	104.85^{abc}
AHSG-19	17.98^{cd}	22.13^{cd}	19.32^{bc}	21.13^{bcdef}	93.21^{bc}	98.67^{bcdef}
AHSG-20	16.16^{def}	20.10^{def}	17.68^{cde}	18.77^{cdef}	77.32^{e}	85.49^{fg}
AHSG-21	16.06^{def}	22.07^{cd}	17.68^{cde}	20.73^{cdef}	89.20^{cd}	93.32^{cdefg}
AHSG-22	13.26^{g}	16.83^{g}	13.90^{g}	16.23^{f}	86.06^{cde}	98.09^{bcdefg}
AHSG-23	24.59^{a}	28.43^{a}	25.48^{a}	27.73^{a}	107.27^{a}	116.78^{a}
AHSG-25	16.92^{cde}	23.99^{bc}	18.51^{cd}	22.53^{bcd}	90.65^{cd}	99.30^{bcde}
AHSG-27	17.61^{cde}	21.24^{cde}	18.76^{cd}	20.17^{cdef}	74.60^{e}	86.72^{efg}
AHSG-28	20.93^{b}	26.22^{ab}	21.47^{b}	26.20^{ab}	103.16^{ab}	107.59^{ab}
AHSG-29	17.36^{cde}	21.88^{cd}	17.69^{cde}	22.07^{bcde}	94.98^{bc}	100.55^{bcd}
AHSG-30	18.78^{c}	24.13^{bc}	20.03^{bc}	23.5^{abc}	91.53^{bc}	92.95^{cdefg}
AHSG-31	17.22^{cde}	19.75^{defg}	18.16^{cde}	19.23^{cdef}	79.15^{de}	88.84^{defg}
AHSG-32	18.13^{cd}	21.62^{cde}	18.84^{cd}	21.50^{bcdef}	91.13^{c}	96.06^{bcdefg}
AHSG-34	15.34^{efg}	20.51^{def}	15.85^{efg}	20.40^{cdef}	92.49^{bc}	99.09^{bcdef}
CD (p=0.05)	1.998	2.611	2.092	4.777	10.546	11.792
SEm±	0.689	0.900	0.721	1.646	3.634	4.063
SEd±	0.974	1.273	1.019	2.328	5.139	5.746
CV	6.988	7.215	6.882	13.694	7.054	7.280

Genotypes	Fruit length (cm)		Fruit weight (g)			
	SS 2023	RS 2023	SS 2022	RS 2022	SS 2023	RS 2023
AHSG-16	77.52^{e}	81.8^{d}	1.13^{gh}	1.69^{gh}	1.17^{fg}	1.67^{def}
AHSG-17	87.66^{bcde}	92.53^{bcd}	1.20^{fgh}	1.87^{efg}	1.24^{ef}	1.88^{cde}
AHSG-18	99.63^{b}	103.56^{abc}	1.59^{bc}	2.24^{bcd}	1.61^{c}	2.23^{bc}
AHSG-19	96.39^{bc}	96.45^{abcd}	1.30^{efg}	2.05^{def}	1.33^{def}	1.99^{bcd}
AHSG-20	81.00^{de}	82.33^{d}	0.81^{i}	1.45^{h}	0.84^{h}	1.41^{ef}
AHSG-21	91.05^{bcd}	92.4^{bcd}	1.75^{b}	2.42^{bc}	1.80^{b}	2.38^{abc}
AHSG-22	90.37^{bcd}	94.43^{abcd}	0.67^{i}	1.38^{h}	0.71^{h}	1.32^{f}
AHSG-23	111.22^{a}	114.05^{a}	2.13^{a}	2.82^{a}	2.19^{a}	2.75^{a}
AHSG-25	91.58^{bcd}	99.05^{abcd}	1.69^{bc}	2.49^{b}	1.71bc	2.48^{ab}
AHSG-27	77.28^{e}	84.85^{cd}	1.36^{def}	2.02^{def}	1.41^{de}	1.99^{bcd}
AHSG-28	97.20^{bc}	108.04ab	1.23^{efgh}	1.85^{fg}	1.15^{fg}	1.96^{cd}
AHSG-29	90.82^{bcd}	105.74^{ab}	1.41^{de}	2.04^{def}	1.31^{def}	2.15^{bcd}
AHSG-30	87.41^{bcde}	97.43^{abcd}	1.52^{cd}	2.17^{cde}	1.44^{d}	2.26^{bc}
AHSG-31	80.12^{de}	88.18^{bcd}	1.25^{efgh}	1.96^{defg}	1.25^{ef}	1.95^{cd}
AHSG-32	85.92^{cde}	101.68^{abcd}	1.08^{h}	1.83^{fg}	1.01^{g}	1.93^{cd}
AHSG-34	89.29^{bcde}	102.97^{abc}	1.36^{def}	1.92^{efg}	1.28^{def}	2.01^{bcd}

Table 2: Continue...

Genotypes	Fruit length (cm)		Fruit weight (g)			
	SS 2023	RS 2023	SS 2022	RS 2022	SS 2023	RS 2023
CD (p=0.05)	10.623	16.962	0.167	0.267	0.166	0.450
SEm±	3.660	5.845	0.058	0.092	0.057	0.155
SEd±	5.177	8.265	0.082	0.130	0.081	0.219
CV	7.072	10.480	7.437	7.907	7.395	13.279

RS: Rainy season; SS: Summer season

Table 3: Morphological characterization of important sponge gourd lines

Sl. No.	Genotype	Leaf shape	Fruit skin colour	Fruit shape	Seed colour
1.	AHSG-16	Ovate	Medium green	Elongate elliptical	Black
2.	AHSG-17	Orbicular	Medium green	Elongate elliptical	Black
3.	AHSG-18	Ovate	Medium green	Elliptical	Black
4.	AHSG-19	Orbicular	Light green	Elliptical	Black
5.	AHSG-20	Ovate	Medium green	Elliptical	Black
6.	AHSG-21	Orbicular	Medium green	Elongate Slim	Black
7.	AHSG-22	Ovate	Light green	Elongate elliptical	Black
8.	AHSG-23	Reniform	Dark Green	Elongate Slim	White
9.	AHSG-25	Ovate	Light Green	Elongate elliptical	Black
10.	AHSG-27	Ovate	Light green	Elliptical	Black
11.	AHSG-28	Ovate	Medium green with strips	Elongate elliptical	Black
12.	AHSG-29	Orbicular	Light green	Elliptical	Black
13.	AHSG-30	Reniform	Dark Green	Elongate elliptical	Black
14.	AHSG-31	Ovate	Light green	Elliptical	Black
15.	AHSG-32	Ovate	Medium green	Elongate elliptical	Black
16.	AHSG-34	Ovate	Medium green	Elongate elliptical	Black

showed maximum fruit length (24.59–28.43 cm), fruit weight (107.27–116.78 g) followed by AHSG-28 (FL: 20.94–26.22 cm; FW: 97.20–108.04 g). AHSG-23 also produced highest fruit yield plant^{-1} (2.13–2.82 kg) followed by AHSG-25 (1.69–2.49 kg) as recorded over the seasons (SS-2022, RS-2022, SS-2023 and RS-2023). Kumar et al., 2019 studied forty-five sponge gourd genotypes for phenotypic performance and genetic variability for yield and seventeen yield attributing characters. The range for fruit length, fruit weight and fruit yield plant^{-1} were 11.37-25.54 cm, 74.96-124.29 g and 0.26-2.65 kg, respectively. Som et al. 2020 described mean performance and diversity among fifteen sponge gourd genotypes for thirteen morphological traits. They found significant variation in fruit length (8.64-25.14 cm), fruit weight (276.66-560.00 g) and yield (71.41-164.83 q ha^{-1}).

3.3. Qualitative traits

With regards to qualitative traits (Table 3), leaf shape was ovate in AHSG-16, AHSG-18, AHSG-20, AHSG-22, AHSG-25, AHSG-27, AHSG-28, AHSG-31, AHSG-31 and AHSG-34; orbicular in AHSG-17, AHSG-19, AHSG-21 and AHSG-29 and reniform in AHSG-23 and AHSG-30. Light green fruit skin colour was observed in AHSG-19, AHSG-22, AHSG-25, AHSG-27, AHSG-29 and AHSG-31; medium green fruit skin was found in AHSG-16, AHSG-17, AHSG-18, AHSG-20, AHSG-21, AHSG-32 and AHSG-34 while AHSG-28 produced medium green coloured with strips; AHSG-23 and AHSG-30 was characterized for dark green fruit skin colour. Fruit shape was elliptical for AHSG-18, AHSG-19, AHSG-20, AHSG-27, AHSG-29 and AHSG-31; elongate slim fruits was found in AHSG-21 and AHSG-23 while AHSG-16, AHSG-17, AHSG-22, AHSG-25, AHSG-28, AHSG-30 AHSG-32 and AHSG-34 was characterized for having elongate elliptical shaped fruits. All the genotypes having typical black coloured seeds on maturity except AHSG-23 which was having white coloured seeds (Figure 1) in mature fruits making this trait as a morphological marker.

Figure 1: AHSG-23: Mature fruits having white colored seeds

With the white coloured seeds, AHSG-23 was found to be trait-specific genotype, and it might be utilized for studying the inheritance pattern and its correlation with other traits. Mavi et al., 2021 thirty-five sponge gourd genotypes in terms of forty-nine different morphological characters including plant growth, flower, fruit and seed characteristics. Songserm, 2025 also characterized thirteen sponge gourd genotypes for morphological traits viz., cotyledon color, Habit, Stem shape, Leaf shape, Peduncle shape, Peduncle separate from fruit, blossom end fruit shape, stem-end fruit shape, fruit size, fruit shape and fruit ribs. Ram et al., 2023 also characterized parental lines and their hybrids (which were made in line×tester mating design) for different qualitative traits in snowball cauliflower.

3.4. Cluster analysis

In the current study, clustering based on morphological traits were executed on sixteen sponge gourd lines. Four clusters were created by loosely organizing the sixteen genotypes. Table 4 and Figure 2 present the accession distribution within each cluster. Out of four clusters, cluster III had the most genotypes (07), followed by cluster IV (06), cluster II (02), and cluster I (01). The genotypes under investigation have a broader genetic foundation, as evidenced by the highest inter-cluster value (8.73811) among group II and III

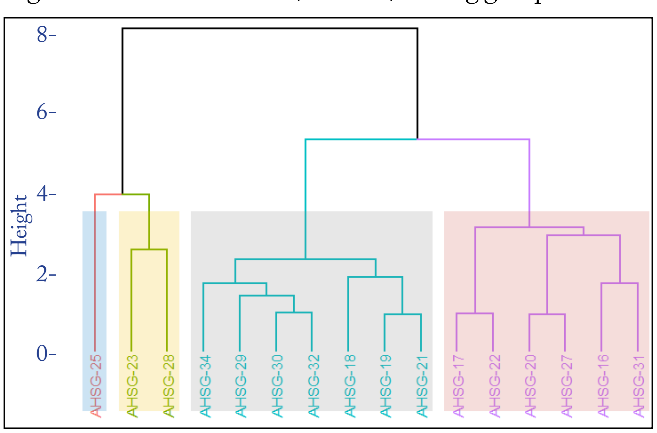

Figure 2: Cluster analysis of sixteen *L. cylindrica* accessions on the basis different traits

Table 4: Summary of clustering pattern of genotypes based on dendrogram

Clusters	No. of accessions	Accessions
Cluster I	01	AHSG-25
Cluster II	02	AHSG-23, AHSG-28
Cluster III	07	AHSG-34, AHSG-29, AHSG-30, AHSG-32, AHSG-18, AHSG-19, AHSG-21
Cluster IV	06	AHSG-17, AHSG-22, AHSG-20, AHSG-27, AHSG-16, AHSG-31

and group III and group I (8.738105). The close association between the genotypes involved was indicated by the least inter-cluster distance (6.982405) among group I and group III, followed by group I and group II (7.003536). Cluster II (5.514662) and Cluster III (5.50402) reported the greatest intra-cluster distances. The intra-cluster distance typically exhibited the smaller values than the inter-cluster distances. Hence, the accession accounts within a cluster were less variation from one another. Choosing promising lines from group with high inter-cluster distance was preferable since it showed that the lines have a greater degree of genetic variation. Thus, these diverse lines might be used in the future improvement programme in the *Luffa cylindrica* for development and selection (Mavi et al., 2018). Mavi et al., 2021 clustered thirty-five sponge gourd genotypes into six different clusters based on ten different growth, fruiting and seed related traits. Choudhary et al., 2011 evaluated 35 genotypes 8 quantitative traits and clustered them into four clusters irrespective of geographic divergence, indicating noparallelism between geographic and genetic diversity. Cluster IV was very large containing 16 genotypes, while cluster III was represented by three genotypes. Kumar et al., 2019 grouped forty-five g sponge gourd genotypes into 7 different non-overlapping clusters. Out of the seven clusters, cluster-I was largest comprising 18 genotypes, followed by cluster-II comprising 12 genotypes, cluster-III with 9 genotypes, cluster-IV with 3 genotypes. Three clusters were single genotype clusters, these clusters were V, VI and VII. Marr et al., 2005 used morphological markers like a seed weight, seed length, seed width for assessment of relationships and estimating genetic diversity. The largest sponge gourd accessions' group in current investigation were clustered jointly into a single group, suggesting that there was some association among the phenotypic characters of the various accessions.

4. CONCLUSION

The present study exhibited that sixteen sponge gourd genotypes were diverse based on evaluation and morphological characterization for flowering, fruit harvest, yield traits as well as qualitative traits over the four environments (*Summer* 2022, *kharif*, 2022, *summer*, 2023 and *kharif*, 2023). It showed the existence of considerable genetic variability amongst sponge gourd genotypes (distribute among four clusters). One trait-specific genotype (AHSG-23 possessing white seed colour) were also identified, which can be utilized to study the genetics and inheritance pattern, further.

5. REFERENCES

Altinsik, A., Gur, E., Oldas, S., 2010. A natural sorbent *Luffa cylindrica* for the removal of a modal basic dye. Journal of Hazardous Materials 179(1–3), 658–666. doi: 10.1016/j.jhazmat.2010.03.053.

Bal, K.E., Bal, Y., Lallam, A., 2004. Gross morphology and absorption capacity of cell fibers from the fibrous vascular system of Loofah (*Luffa cylindrica*). Textile Research Journal 74(3), 241–247. https://doi.org/10.1177/004051750407400310.

Bhutia, N.D., Sureja, A.K., Verma, M., Gopala Krishnan S., Arya, L., Bhardwaj, R., Dash, P.K., Munshi, A.D., 2023. Inheritance and molecular mapping of solitary/cluster fruit-bearing habit in *Luffa*. Molecular Genetics and Genomics 298, 995–1006. https://doi.org/10.1007/s00438-023-02034-0.

Chandra, U., 1995. Distribution, domestication and genetic diversity of *Luffa* gourd in Indian subcontinent. Indian Journal of Plant Genetic Resources 8, 189–196. https://indianmedicine.eldoc.ub.rug.nl/68039/.

Cho, S.E., Hong, S.H., Kim, B.S., Kim, J.Y., Shin, H.D., 2015. First report of powdery mildew caused by Podosphaera xanthii on *Luffa cylindrica* in Korea. Plant Disease 99 (12), 1861. https://doi.org/10.1094/PDIS-05-15-0518-PDN.

Choudhary, B.R., Pandey, S., Singh, P.K., Singh, R., 2011. Genetic divergence in hermaphrodite ridge gourd (*Luffa acutangula*). Vegetable Science 38(1), 68–72. DOI: https://doi.org/10.61180/.

Gong, Y., Luo, X., Zhang, T., Zhou, G., Li, J., Zhang, B., Li, P., Huang, H., 2024. Assembly and comparative analysis of the complete mitochondrial genome of white towel gourd (*Luffa cylindrica*). Genomics 116(3), 110859. https://doi.org/10.1016/j.ygeno.2024.110859. https://www.sciencedirect.com/science/article/pii/S0888754324000806.

Harshitha, S., Sood, M., Indiresh, K.M., 2019. Variability and heritability studies for horticultural traits in ridge gourd [*Luffa acutangula* (L.) Roxb.]. International Journal of Bio-resource and Stress Management 10(4), 335–339. https://www.ojs.pphouse.org/index.php/IJBSM/article/view/3838.

Islam, S., Munshi, A.D., Verma, M., Arya, L., Mandal, B., Behera, T.K., 2011. Screening of *Luffa cylindrica* Roem for resistance against Tomato leaf curl New Delhi virus, inheritance of resistance, and identification of SRAP markers linked to the single dominant resistance gene. Journal of Horticultural Science and Biotechnology 86(6), 661–667. doi: 10.1080/14620316.2011.11512819.

Kalloo, G., 1993. Loofah-luffa spp. In: Genetic improvement of vegetable crops (Pergamon Press, UK), 265–266. doi: 10.1016/B978-0-08-040826-2.50023-0.

Kumar, J.S., Pandit, M.K., 2022. Genetic variability, diversity, heterosis and combining ability in sponge gourd [*Luffa cylindrica* (Roem.) L.]. International Journal of Bio-resource and Stress Management 13(10), 1047–1056. DOI: HTTPS://DOI.ORG/10.23910/1.2022.3117.

Kumar, J.S., Pandit, M.K., Pathy, T.L., 2019. Genetic variability, diversity and character association in sponge gourd [*Luffa cylindrica* (Roem.) L.]. International Journal Current Microbiology and Applied Science 8(3), 278–90. DOI:10.20546/ijcmas.2019.803.035.

Liu, L., Wang, R., He, W., He, F., Huang, G., 2010. Cloning and soluble expression of mature alpha-luffin from *Luffa cylindrica* and its antitumor activities in vitro. Acta Biochimica et Biophysica Sinica (Shanghai) 42(8), 585–592. https://doi.org/10.1093/abbs/gmq056.

Marr, K.L., Bhattarai, N.K., Xia, Y., 2005. Allazymic, morphological, and phenological diversity in cultivated *Luffa acutangula* from China, Laos, and Nepal, and allozyme divergence between *L. acutangula* and *L. aegyptiaca*. Economic Botany 59(2), 154–165. https://link.springer.com/article/10.1663/0013-0001(2005)059 [0154:AMAPDI]2.0.CO;2.

Mashilo, J., Shimelis, H., Ngwepe, M.R., 2025. Genetic improvement and innovations of sponge gourd (*Luffa cylindrica* L.): An opportunity crop. Industrial Crops and Products 225, 120430. https://doi.org/10.1016/j.indcrop.2024.120430.

Mavi, K., Gunduz, K., Uzunoglu, F., Karaat, F., 2021. Morphological characterization of sponge gourd (*Luffa aegyptiaca* Mill.) genotypes from the Eastern Mediterranean Region of Turkey. Genetika 53(3), 1043–1064. DOI: 10.2298/GENSR2103043M.

Mavi, K., Gunduz, K., Yildirim, D., Uzunoglu, F., 2018. Seed characteristics diversity in sponge gourd (*Luffa aegyptiaca* Mill.) germplasms from Hatay region in Turkey. Bulletin UASVM Horticulture 75(1), 40–46. https://www.cabidigitallibrary.org/doi/pdf/10.5555/20183382974.

Oboh, I.O., Aluyor, E.O., 2009. *Luffa cylindrica*-an emerging cash crop. African Journal of Agriculture

Research 4(8), 684–688. https://academicjournals.org/article/article1380901301_Oboh%20and%20Aluyor.pdf.

Pal, R.K., Manoj, J., 2011. Hepatoprotective activity of alcoholic and aqueous extracts of fruits of *Luffa cylindrica* Linn in rats. Annals of Biological Research 2(1), 132–141. https://www.scholarsresearchlibrary.com/articles/hepatoprotective-activity-of-alcoholic-and-aqueous-extracts-of-fruits-of-luffa-cylindrica-linn-in-rats.pdf.

Porterfield, W.M., 1955. Loofah-the sponge gourd. Economic Botany 9, 211–223. Doi: 10.1007/BF02859814.

Prakash, K., Pati, K., Arya, L., Pandey, A., Verma, M., 2014. Population structure and diversity in cultivated and wild *Luffa* species. Biochemical Systematics and Ecology 56, 165–170. https://doi.org/10.1016/j.bse.2014.05.012.

Rai, S., Sarkar, R.K., Roy, S.K., Dutta, S., Rai, U., Rai, S., Debnath, A., Sindhu, V., 2025. Estimates of genetic variability, heritability and genetic advance for yield and yield component traits in ridge gourd (*Luffa acutangula* Roxb.). International Journal of Bio-resource and Stress Management 16(3), 01–13. DOI: HTTPS://DOI.ORG/10.23910/1.2025.6003.

Ram, H., Sureja, A.K., Dey, S.S., 2023. Morphological characterization, combining ability and heterosis for important horticultural traits in snowball cauliflower (*B. oleracea* var. *botrytis* L.). Plant Genetic Resources: Characterization and Utilization 21(02), 131–142. https://doi.org/10.1017/s1479262123000539.

Sharma, N.K., Keshari, P., Jha, K., Singh, H.K., Shrivastava, A.K., 2014. Hepatoprotective activity of *Luffa cylindrica* (L) M.J. roem leaf extracts in Paracetamol intoxicated rats. Indian Journal of Natural products and Resources 5(2), 143–148. DOI: 10.56042/ijnpr.v5i2.12454.

Sidhu, M.K., Kaur, J., 2021. Interspecific hybridization between sponge gourd (*Luffa cylindrica* L.) and 'Satputia' (*Luffa hermaphrodita* Singh and Bhandari) for preintrogression of cluster bearing, high yield and gynoecism. Journal of Genetics 100, 73. https://doi.org/10.1007/s12041-021-01323-0.

Som, I., Kunjam, K., Thakur, R., 2020. Genetic variability of sponge gourd (*Luffa cylindrica* L. Roem.) and it's morphological characterization. Journal of Pharmacognosy and Phytochemistry 9(1), 235–37. https://www.phytojournal.com/archives/2020/vol9issue1/PartD/8-6-342-596.pdf.

Songserm, A., 2025. Morphological characterization of sponge gourd for utilization in plant germplasm conservation. King Mongkut's Agricultural Journal 43(3), 486–495. DOI: https://doi.org/10.55003/kmaj.2025.06.30.018.

Yawalkar, K.S., 2004. Cucurbitaceous or vine crops. In: Vegetable crop of India (V.ED.), pp. 152–155. ISBN:8190039238. https://archive.org/details/vegetablecropsof0000ksya/page/n1/mode/2up.