Volume 43 (2)
March 2022

JEB®

Journal of Environmental Biology

p-ISSN: 0254-8704 • e-ISSN: 2394-0379 • CODEN : JEBIDP

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1/206, Vikas Nagar
Lucknow, India

JEB®

Journal of Environmental Biology

p-ISSN: 0254-8704 • e-ISSN: 2394-0379 • CODEN: JEBIDP

Journal website : www.jeb.co.in ★ **E-mail :** editor@jeb.co.in

Triveni Enterprises (Educational Services Set-up)

Original Research

DOI : http://doi.org/10.22438/jeb/43/2/MRN-1927

Standardization of seed, rootstock and plant standards of *lasoda* (*Cordia myxa* L.) for commercial orcharding in India

K. Kumar[1]*, D.K. Sarolia[2], P.L. Saroj[3], D.K. Samadia[4] and D. Singh[5]

[1]Division of Crop Improvement, ICAR- Central Institute for Arid Horticulture, Bikaner-334 006, India
[2]Division of Crop Production, ICAR- Central Institute for Arid Horticulture, Bikaner-334 006, India
[3]ICAR- Central Institute for Arid Horticulture, Bikaner-334 006, India
[4]Post Harvest Technology & Transfer of Technology, ICAR- Central Institute for Arid Horticulture, Bikaner-334 006, India
[5]Division of Crop Improvement, ICAR- Central Institute for Arid Horticulture, Bikaner-334 006, India

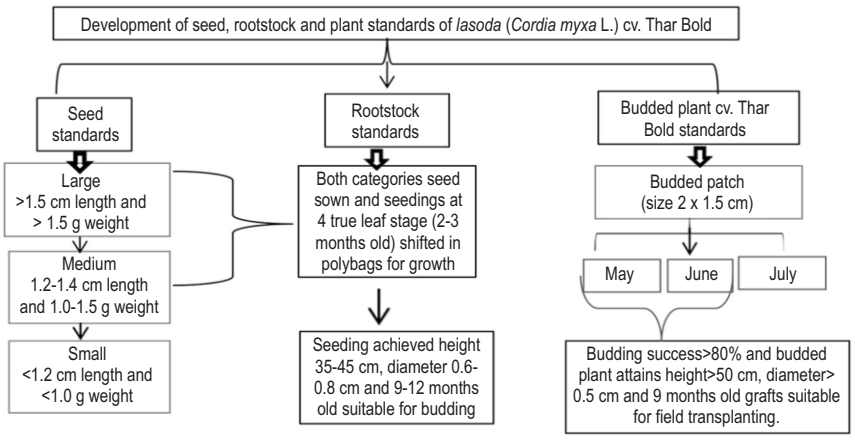
***Corresponding Author Email :** kamlesh.kumar2@icar.gov.in

Received: 02.04.2021 *Revised*: 21.07.2021 *Accepted*: 25.09.2021

Abstract

Aim: The present study was conducted to develop the planting material standards of *lasoda* cultivar 'Thar Bold' for commercial orcharding in India.

Methodology: The ripe fruits at pink colour appearance from mother tree of *lasoda* 'Thar Bold' were collected from Experimental Block-I after 75+5 days after fruit set during last week of May-first week of June months for raising of seedlings. Fruits and seeds were categorized based on size and weight and accordingly seeds sown in field bed and root trainers. At two true leaf stage, the seedlings were shifted in polybags for working out seed and rootstock standards. Further, to develop the planting material standards, the scion buds of current season's growth were collected and budded during third week of May, June and July. The standards were prepared on the basis of all possible traits of the interest.



Results: Under the present study, planting material standards of *lasoda* were developed with following prerequisites: ripened fresh fruits should have diameter > 1.5 cm and fruit weight > 6 g with seed germination > 60 %; buddable seedlings/ rootstock of 9-12 months should have about 35-40 cm height and 0.8-1.0 cm girth; budding should be done during May-June months; at 90 days of budding, plants with sprouts length ≥ 50 cm and diameter ≥ 0.5 cm should be good for field planting in the same season.

Interpretation: The developed standards of *lasoda* would be highly useful for conservation of elite type and large scale multiplication of quality planting material for commercial orcharding in the country.

Key words: *Cordia myxa*, Orchards, Rootstock, Seed standards

How to cite : Kumar, K., D.K. Sarolia, P.L. Saroj, D.K. Samadia and D. Singh: Standardization of seed, rootstock and plant standards of lasoda (*Cordia myxa* L.) for commercial orcharding in India. *J. Environ. Biol.*, **43**, 267-275 (2022).

Introduction

Underutilized fruit crops appear to be the future crops of hope and need prime attention, as it can provide nutritional security and sustain the ill impact of climatic vagaries. Thereby, world-wide underutilized fruit crops are becoming popular due to their unique adaptation mechanisms to harsh conditions like; high temperatures, drought and poor soils etc. Indian originated underutilized fruit crops such as karounda (*Carissa carandas*), *ker* (*Capparis decidua*), *pilu* (*Salvadora persica*), *phalsa* (*Grewia subinaequalis*), *lasoda* (*Cordia myxa*) etc. are being utilized in many forms by human beings living in hot arid and fragile ecosystems (Kumar *et al.,* 2018). *Lasoda* (*Cordia myxa*) is one of them, which is known by several other names *viz., lehsua, gunda, goondi, glue* berry (due to mucilaginous pulp), Assyrian plum, Bird's nest, Indian cherry and cherry of the desert etc (Saroj and Awasthi, 2006). This crop has many advantages in terms of ease in growing, hardy nature and good yield even under extreme weather conditions. Consumption of *lasoda* fruits has its own history because local people are well aware of their nutritional and medicinal values.

This fruit is the great sources of livelihood for the poor and play an important role in overcoming the problem of malnutrition in inhabitants of arid and semi-arid regions (Gajanana *et al.,* 2010). Almost all plant parts of *lasoda* are used for one or other purposes. The fresh tender fruits are used for making vegetable and pickles. *Lasoda* wood is generally used for making agricultural implements, ornamental furniture, house-posts, sword sheaths, beams, spokes, toys, bowls, wooden utensils for kitchen etc. (Saroj and Awasthi, 2006; Sivalingam *et al.,* 2012). For improving this crop, selection of high yielding genotypes with desirable characters from seedling population and perpetuation of the same by clonal propagation is the best strategy. Since improved cultivars of *lasoda* are not available for commercial growing, therefore, based on size of the fruits (big and small) nurserymen propagating and selling in the name of big and small fruited *lasoda*. Small fruited types locally called as goondi are much liked by rural people of Rajasthan and Gujarat.

This fruit tree has not yet been utilized as an orchard crop, though its importance and uses are well known (Sivalingam *et al.,* 2012). However, only few named varieties were released for cultivation. For the first time in Rajasthan, a big fruited *lasoda* variety was recognized as 'Thar Bold' from ICAR-CIAH, Bikaner (Saroj and More, 2012) that possesses vigorous growth habit, medium statured, broad leaved, deciduous nature having mean height about 5-6 meter. The selected cultivar of *lasoda* is in huge demand by growers because of good quality big fruit size, more pulp content and medium stone size. Based on big fruit size, high fruit yield potential and other desirable attributes of 'Thar Bold'; Kumar and Haldhar (2021) also suggested for its commercial exploitation. The variety 'Thar Bold' can withstand to drought some extent and can tolerate temperature as high as 48°C during the summer months especially in arid region of Rajasthan. Good quality and healthy planting materials is the key point of a successful orcharding which is lacking in case of *lasoda*. The demand for quality planting material of fruit crops including *lasoda* has increased manifold throughout the country in the recent past. However, the greatest bottleneck in the expansion of area under fruits is the non-availability of genuine and quality planting material in adequate quantity from reliable sources. More often farmers have to get the plants from unreliable sources and this practice is causing great harm to the fruit industry of the country. The targets of the enhancing fruit production in the coming years will be achieved only through production and distribution of healthy, genuine and quality planting material of commercial/ improved varieties of fruit crops in sufficient quantities.

The maintenance of purity is easy in vegetatively propagated fruit crops as compared to seed propagated ones, still it requires a close monitoring at different stages in the nursery to produce disease and pest free planting materials. (Reddy and Shukla, 2019). *Lasoda* can be propagated both by seeds and vegetative means but generally it is propagated by freshly extracted seeds due to least availability of vegetatively multiplied quality planting materials (Kumar and Haldhar, 2021). However, being a cross pollinated crop, seed propagation is not advisable as seed multiplied population gives greater variability in terms of plant vigour, bearing behaviour, fruit yield and quality parameters. Clonal propagation through patch budding was attempted by Singh *et al.* (2003) and Meghwal (2007) with varying level of success, which needs further validation.

In spite of good potential of *lasoda* fruits both ripe and unripe, it is still unexplored and underutilized crop because of least varietal wealth for commercial cultivation and also no planting material standards are available, so as to enter into area expansion programme. Therefore, the present study was undertaken to develop seed and planting material standards of *lasoda* cultivar 'Thar Bold' at ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan).

Materials and Methods

Experimental site and weather conditions: To develop the planting material standards of *lasoda* cv. 'Thar Bold', the experiments were conducted during 2018 to 2020 in Nursery Unit of ICAR-Central Institute for Arid Horticulture (ICAR-CIAH), Bikaner. The institute is located at 28^0 N latitude, $73^0 18^0$ E longitude and 234.84 m above sea level. The elevate of experimental site is very hot and dry, receiving scanty rains. The maximum and minimum temperatures during experimental period (May 2018 to March 2020) were 43.68 and 4.97^0C, respectively. Similarly, the mean monthly humidity ranged from 27.10 to 76.32% and low seasonal rains varied from 0.00 to 189.80 mm.

Plant material and media composition: To develop seed and rootstock standards of *lasoda* cultivar 'Thar Bold'; the ripe fruits at pink colour stage from mother tree of *lasoda* were collected from Experimental Block-I 75+5 days after fruit set during last week of May- first week of June for raising of seedlings. Fruits were collected from single mother tree of *lasoda* which was earlier identified as 'Thar Bold' at institute for big fruits and higher fruit yield. Therefore, the mother tree was selected for the present study to develop the planting material standards.

The seeds were extracted from pink ripe fruits and demucilaged in running water. The extracted seeds were categorized as bold, medium and small, based on size and weight. Thereafter, 160 seeds were sown each in field bed (1m x 2 m) and in root trainers (40 cell 100 cc) after treating with copper oxychloride @ 2.5 g kg^{-1} of seed. Proper watering and protection from squirrels and birds were done. Observations were recorded with respect to pre germination as fruit size and weight, seed weight, seed index (100 seed weight) as well as days taken in germination and per cent germination. The raised seedlings under both the conditions after 2-3 weeks at two true leaf stage were shifted in polybags containing mixture of soil: pond silt: FYM in the ratio of 2:1:1, respectively, for rootstock standards. The height and diameter of seedlings were recorded at 15 days interval up to 75 days after shifting. Besides the number of leaves, length of internode, length of tap root, diameter of collar end, biomass, root: shoot ratio, seedling vigour etc., were recorded during shifting in polybags and 75 days after shifting.

Budding experiment: To study the planting material standards for quality plant production, the scion buds from middle portion of current season's growth were collected from 'Thar Bold' mother *lasoda* tree during third week of May, June and July months and budded on already raised seedling rootstocks. The basic reason of selecting the middle portion of current season's growth were if basal portion is used it has less prominent buds, and if upper portion is used it is difficult to separate buds from scion shoot due to very tender portion. Therefore, the middle portion was selected so as to get prominent buds for budding purpose and thereby better success of bud graft. Patch budding was done on 9 to 12 months old rootstocks in each month as mentioned above, having 45 plants per treatment. The matrix height on rootstock was about 18.3 to 18.8 cm above the ground level. The data were recorded on number of days taken for bud sprout, bud sprout period, bud sprout success, budded plant survival and mortality rate, sprout length and sprout diameter. Ten uniform budded plants were selected for recording plant height and number of leaves per plant and plants ready for transplanting (attaining a height of about 50-55 cm). These budded plants were further transplanted in field to assess the establishment and survival of *lasoda* plants under field conditions.

Statistical analysis: The experiment was conducted in a completely randomized block design with three replications and data were analyzed using software developed by Sheoran *et al.* (1998).

Results and Discussion

In the present study, all fruits at pink ripe stage were harvested from a lasoda tree of cultivar Thar Bold and categorized into three groups *viz.,* small, medium and bold based on size and weight. The results of harvested ripe fruits on a tree revealed (Table 1) that the maximum fruits were observed under medium categories (53%) followed by bold (26%) and least in small category (21%). The weight of 100 fruits varied from 0.42 kg (small) to 1.13 kg (bold). The maximum fruit size and weight (>2.5 cm and >10 g) were recorded in bold categories followed by medium (1.5-2.5 cm and 6.0-10.0 g) and minimum in small category (<1.5 cm and <6.0 g), respectively. Similar trends were also found with respect to seed size and weight and the maximum seed size and weight (>1.5 cm and >1.5 g) were observed in bold categories followed by medium (1.2-1.4 cm and 1.0-1.5 g) and least in small category (<1.2 cm and <1.0 g), respectively.

The results of the present study are in close confirmity with the findings of Samadia (2007); Kaushik and Dwivedi (2004); Nagar *et al.* (2013); Zanuncio *et al.* (2020) in *lasoda* and Kumar *et al.* (2015) in mandarin for fruit and seed characteristics. Zanuncio *et al.* (2020) also found varying degree of length and diameter of fruits and seeds of *Cordia trichotoma*. They reported average length of seeds 8.69 ± 0.62 mm and a mean diameter of 4.49 ± 2.27 mm and on the basis of biometrics grouped the seeds into two classes) less than 4 mm and) larger or equal to 4 mm diameter. Kumar *et al.* (2015) concluded that the large size fruits had more number of bold seeds per fruit as compared to smaller one, therefore bold seeds can be used for nursery raising for getting better germination and faster seedlings growth. Data on seed germination behaviour presented in Table 2 clearly indicate that the germination of seeds sown in plug trays was early and better over seed beds. Also, seed germination was better in bold seeds, followed by medium and small seeds. Further, freshly extracted seeds sown in plug trays gave maximum germination in all categories of seeds, which varied from 43.0 - 72.5 per cent.

The germination of *lasoda* seeds declined with the advancement of storage days and recorded 24.0 – 56.0% on 6^{th} day of storage under small and bold seed categories, respectively. Moreover, the seeds sown in seed beds, germination per cent from fresh as well as 6^{th} day stored was more or less similar in small categories (42.0 and 25.0%), and reduced in medium (60.0 and 36.5%) and bold categories (65.3 and 45.0%) seeds, but over all poor as compared to plug tray sown seeds (Table 2). Feshly extracted seed gave maximum germination due to high temperature (43.44^{0}C), and relative humidity (85.87%) favoured the germination, long stored seeds and and low humidity reduced the germination per cent in all categories of seeds in the present study (Fig. 1). Zanuncio *et al.* (2020) reported similar kind of results while studying seed germination and seedling production at different levels of temperatures in *Cordia trichotoma* seeds. They obtained maximum seed germination in shortest time and seedling growth with higher temperature (30^{0}C) regime as compared to lower temperature (25^{0}C). The findings of Meghwal and Roy (2011) also supported the present study and observed 50-60 per cent seed germination in *lasoda* under Jodhpur climatic conditions. Galíndez *et al.* (2019) reported that both temperature and moisture content are key factors in *lasoda* for better germination while working on different species of *Cordia* for studying seed germination and storage behaviour. They observed 7 to 9 days delay and poor germination in *Cordia americana* and *Cordia saccelia* due to storage, and no germination was observed after one year of storage in *C. americana* and *C. trichotoma*. Further, they concluded that some populations within a species were more sensitive to desiccation and storage conditions than others, and

Table 1: Categorization of fruits and seeds of *lasoda* cultivar 'Thar Bold' before sowing

Parameters	Category		
	Small	Medium	Bold
Average ripe fruits on a tree (%)	21.0	53.0	26.0
Average fruit size (cm)	<1.5 cm	1.5-2.5 cm	>2.5 cm
Average fruit weight (g)	< 6.0g	6.0-10.0 g	>10.0 g
Average seed length (cm)	<1.2 cm	1.2-1.4 cm	>1.5 cm
Average seed weight (g)	<1.0 g	1.0-1.5 g	>1.5 g

Table 2: Per cent germination of *lasoda* seeds at different time intervals in plug trays

Seed categories	Days										
Plug tray sown	0	2	4	6	8	10	12	14	16	18	20
Small	43.0 (40.9*)	34.5 (35.9)	26.0 (30.5)	24.0 (29.2)	24.0 (29.2)	19.0 (22.8)	7.0 (15.2)	6.5 (14.6)	3.0 (9.8)	0.0 (0.0)	0.0 (0.0)
Medium	70.0 (54.1)	47.5 (43.5)	46.5 (43.0)	46.0 (42.7)	43.0 (40.9)	34.0 (35.6)	19.5 (26.1)	15.5 (23.1)	10.0 (18.4)	1.0 (5.2)	0.0 (0.0)
Bold	72.50 (58.4)	61.0 (51.3)	60.5 (51.1)	56.0 (48.5)	39.0 (38.6)	37.0 (37.4)	28.5 (32.2)	21.0 (27.2)	11.5 (19.8)	2.0 (8.0)	1.0 (4.78)
SEm+CD	1.71	0.67	1.76	1.59	0.92	0.78	0.95	0.75	0.60	1.64	0.75
(p=0.05)	5.12	2.03	5.27	4.78	2.76	2.16	2.85	2.25	1.80	1.92	2.24
Seed bed sown											
Small	42.0 (40.4)	29.5 (32.9)	25.0 (29.9)	25.0 (29.9)	22.8 (28.5)	19.0 (25.8)	10.0 (18.8)	6.3 (14.4)	1.0 (5.2)	0.0 (0.0)	0.0 (0.0)
Medium	60.0 (50.7)	40.0 (39.2)	37.5 (37.7)	36.5 (37.1)	30.6 (33.5)	27.5 (31.6)	18.0 (25.0)	10.0 (18.4)	5.5 (13.5)	1.0 (4.2)	0.0 (0.0)
Bold	65.3 (53.9)	50.9 (45.5)	48.8 (44.2)	45.0 (42.1)	33.5 (35.)	30.0 (32.3)	20.0 (26.5)	12.0 (20.2)	7.3 (15.6)	1.0 (12.2)	1.0 (4.78)
SEm+CD	0.67	1.09	1.69	1.01	0.70	0.56	0.76	0.56	0.74	4.51	0.75
(p=0.05)	2.01	3.25	5.67	3.04	2.10	1.70	2.27	1.67	2.23	NS	2.24

* Values in parenthesis are angular transformation

Table 3: Seedling height (cm) and diameter (cm) of *lasoda* after shifting in polybags from seed bed and plug tray sown conditions

Category of seed	Days after shifting					
	30		60		90	
	Height	Diameter	Height	Diameter	Height	Diameter
Seed bed grown						
Small	9.75	0.30	19.25	0.35	29.74	0.52
Medium	14.25	0.32	25.15	0.48	35.33	0.70
Bold	16.25	0.37	26.00	0.49	40.23	0.75
SEm+	0.53	0.01	0.56	0.02	0.86	0.01
CD (p=0.05)	1.59	0.04	1.67	0.05	2.58	0.03
Plug tray grown						
Small	11.00	0.26	26.12	0.36	34.71	0.57
Medium	17.00	0.47	35.15	0.49	47.66	0.78
Bold	21.00	0.38	37.20	0.50	49.78	0.80
SEm+	0.62	0.01	1.03	0.02	0.68	0.01
CD (p=0.05)	1.84	0.03	3.10	0.06	2.03	0.04

prevailing local environmental conditions can influence seed germination in *Cordia species*. Therefore, it is obvious from the study that only freshly extracted seeds should be shown to get better germination in *lasoda*. Prolonging storage period of *lasoda* may lead to poor and reduced germination because of loss of seed viability during storage. Under ordinary conditions, the *lasoda* seeds lose viability during storage, so, they should be sown immediately after extraction (Meghwal and Singh, 2021).

Data on seedling/rootstock height and diameter given in Table 3 shows that both parameters gradually increased with advancement of days either sown in plug trays or in seed beds. In

Table 4: Seedling parameters of *lasoda* at shifting time and 90 days after shifting (DAS) in polybags from seedbed and plug tray conditions

Category of seeds	Internodal length (cm)		Length of tap root (cm)		Diameter of collar end (mm)		Biomass of seedling (g)		Root/ shoot ratio		Seedling vigour index		Per cent buddable attainment	
	0 DAS	90DAS	0 DAS	90DAS	0 DAS	90DAS	0 DAS	90DAS	0 DAS	90DAS	0 DAS	90DAS	75 DAS	90DAS
Seed bed grown														
Small (<1.2cm)	1.20	2.23	4.00	20.80	2.40	7.99	4.32	17.77	0.69	0.70	209.95	1073.98	27.78	33.55
Medium (1.2-1.4 cm)	1.40	3.18	4.20	27.00	3.23	9.50	6.87	24.43	0.51	0.77	360.24	1791.99	47.22	59.66
Bold (>1.5 cm)	1.80	4.80	4.80	27.62	3.72	9.76	7.75	25.62	0.50	0.69	527.44	2459.56	52.77	63.47
SEm+CD	0.08	0.17	0.13	0.48	0.13	0.22	0.21	0.53	0.03	0.02	9.30	18.56	0.31	0.46
(p=0.05)	0.22	NS	0.37	1.36	0.38	0.62	0.60	1.53	0.08	0.05	26.64	53.15	0.88	1.31
Plug tray grown														
Small (<1.2cm)	1.55	2.25	6.30	23.80	2.90	9.47	6.66	18.36	0.96	0.69	275.61	1243.34	30.60	40.33
Medium (1.2-1.4 cm)	1.79	3.30	7.05	29.30	3.99	10.10	9.70	26.93	0.70	0.62	498.81	2212.60	52.50	61.25
Bold (>1.5 cm)	2.03	4.93	7.88	32.26	4.20	10.80	9.87	31.8	0.66	0.65	724.28	2973.95	58.60	66.53
Sem+CD	0.10	0.22	0.16	0.58	0.16	0.26	0.26	0.66	0.03	0.02	11.40	22.73	0.37	0.56
(p=0.05)	0.27	0.62	0.46	1.67	0.47	0.76	0.73	1.88	0.10	NS	32.63	65.10	1.08	1.60

Table 5: Effectof time of budding on success, survival and growth of budded plants

Parameters	Time of budding			SEm±	CD 5%
Budding height on rootstock (cm)	18.7	18.3	18.8	0.18	NS
Rootstock diameter at budding height (cm)	9.13	9.05	9.17	0.33	NS
Days taken to bud sprout (days)	9.07	15.33	19.53	0.45	1.61
Completion of bud sprout (days)	12.00	20.67	23.33	0.63	2.25
Budding success (%)	86.67	64.44	37.78	3.62	12.80
Budded plant survival (%)	82.22	60.00	35.55	2.87	10.12
Sprout length (cm)	52.81	40.65	36.91	0.92	3.26
Sprout diameter (mm)	5.02	4.07	3.56	0.05	0.19
Plant height (cm)	70.64	58.08	52.65	3.63	12.80
Number of leaves/ plant	11.87	10.27	8.67	0.25	0.91
Plants ready for transplanting (days)	85-90	110-120	130-150	–	–

general, growth of plug tray grown seedlings was better over seed bed. At the end of experiment, *i.e.*, 90 days after transplanting, the maximum seedling height (49.78 cm) and diameter (0.80 cm) were recorded in bold category seeds under plug tray condition followed by same growing condition in medium categories (47.66 cm and 0.78 cm) of seed and minimum in small seed categories (29.74 cm and 0.52 cm) under seed bed grown condition. This might be due to seed size and growing media used in seed bed (Soil: vermicompost) and plug tray (Cocopeat and vermiculite), which maintained suitable physical properties and moisture for germination and growth (Birader *et al.*, 1998; Bachman and Metzger, 2008; Zanuncio *et al.*, 2020). Bohra *et al.* (2020) studied different substrate media on plant growth characteristics of banana and reported improved seed germination, shoot length, root length, number of leaves per seedling, collar thickness and seedling vigour index as compared to control (soil) when combination of vermicompost, soil and cocopeat was used as substrate. Therefore, the superiority of growing media used in the present study was clearly evident. Improved germination and seedling growth parameters could be due to the fact that vermicompost and cocopeat are well known to maintain water and nutrient balance for nursery growing plants (Bohra *et al.,* 2019).

Data was recorded on different seedling parameters at the time of shifting in polybags from seed bed and plug tray conditions and recorded incremental progress in all parameters, except root: shoot ratio in both the conditions (Table 4). Overall plug tray grown seedlings were better with respect to length of tap root, diameter of collar end, biomass of seedlings, seedling vigour and attainment to buddable size. Per cent buddable attainments of seedlings size ranging between 0.7-0.8 cm recorded at 90 days after shifting, which was >60 per cent in bold and medium categories of seeds. The better growth of seedlings in plug tray shifted (seedlings) might be due to the fact that the cocopeat

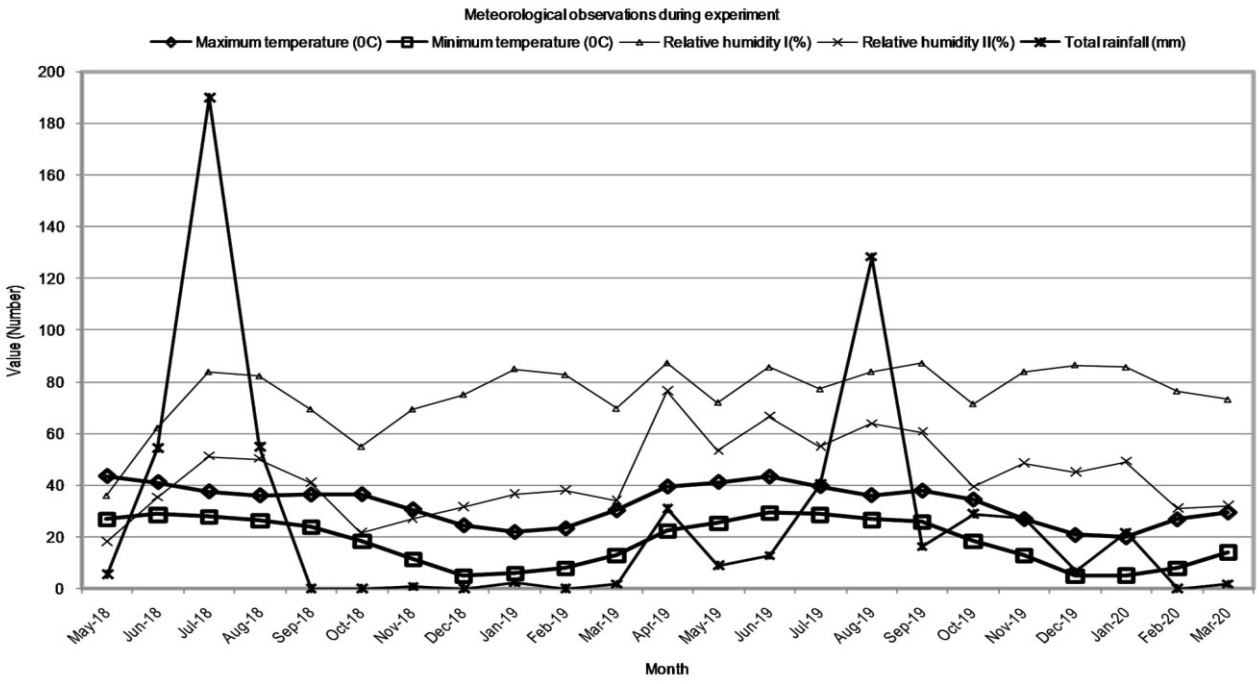


Fig 1: Mean monthly weather parameters during study period (May 2018 to March 2020).

Table 6: Seed, rootstock and plant standards of *lasoda* cultivar 'Thar Bold'

S. No.	Characters	Standards
Fruit and seed	Fruit harvesting stage	Fully ripe at pink colour stage
	Fruit size	>1.5 cm
	Fruit weight	>6.0 g
	Seed longevity (at room temperature)	4-6 days
	Seed size	1.2-1.6 cm
	Seed weight	>1.0 g
	Seed index	>50 g
	Seed sowing	Freshly extracted
Rootstock	Seed germination	> 60 %
	Age of seedling suitable for shifting in polybags (size 25 x 10 cm)	2-3 weeks old with 2-3 leaves
	Seedling height during shifting	5-6 cm
	Seedling age at buddable attainments	5-6 months old
	Seedling height and diameter at 5-6 months	35-45 cm and 0.6-0.8 cm
	Age of rootstock suitable for budding	9-12 months old
Scion	Suitable scion wood	Middle portion from current season's growth
	Diameter of scion shoot	8-10 mm
	Size of bud wood patch	2.0 x 1.5 cm
Planting material	Budding height on rootstock	15-20 cm from upper surface of polybags/ above ground level
	Budding time	May and June month
	Method of budding	Patch budding
	Bud sprout success	80-93.33 (86.67) %
	Plant survival rate	80-86.67 (82.22) %
	Bud sprouts length and diameter after 90 days	50-60 cm and 0.4-0.6 cm
	Plant height after 90 days	65-70 cm
	Number of leaf after 90 days	10-12 per plant
	Plants ready for field planting	Within 90 days from May month budding
	Aftercare/ precautions	Seeds should be treated after demucilaging with any suitable fungicides like copper oxychlorite @ 2.5 g kg^{-1} of seeds. Irrigate budded plants under nursery as and when required. After successful bud unions under nursery, plants always handle by holding the rootstock. Plants should be healthy and free from pest and diseases.

based medium provides a better growth condition for plant establishment, air filled porosity, easily available water and aeration to growing seedlings (Abirami *et al.,* 2010; Bohra *et al.,* 2020). Chopde *et al.* (1999) also reported similar findings in custard apple and obtained maximum seedling heights due to application of cocopeat in media. Bohra *et al.* (2020) observed drastic reduction of seedling vigour index in stored sown seeds as compared to fresh sown. This reduction in vigour may be due to cell membrane permeability in stored seeds due to loss of electrolytes and resulting reduction in vigour of seedlings (Nwauzoma and Moses, 2013). To standardize vegetative propagation of *lasoda* cultivar 'Thar Bold', patch budding was done on seedling rootstock through different months. The data given in Table 5 revealed that the height of budding and diameter of rootstocks at budding height were non significant at different time intervals, though it increased with advancement of budding time. Regarding bud sprouts success, differential degree of response was obtained from May to July.

The time taken in bud sprout was more when budding was done in July (19.53 days) followed by June (15.33 days), while minimum when budding was done in the month of May (9.07 days). Similar trend was there in time taken for completion of bud sprout and almost double time taken when budding was done in July (23.33 days) as compared to May budding (12.00 days). The better bud graft success was obtained when budding was done during May (86.67 %) followed by June (64.44 %) month, and, declined drastically during July (37.78 %). The maximum success of budding was observed in May due to plumpy bud wood of active growth phase with better sap flow and favourable environmental conditions prevailed during study period (Shah *et al.,* 2017). Higher temperature during May to June has helped in early sprouting of buds which may be due to fast development of vascular cambium tissues thereby better healing process at bud graft and made strong union at budding point in rootstock and scion, ultimately resulted in better sprouting and higher plant survival (Kumar *et al.,* 2017).

Bud swell require high temperature (43.68^{0}C) and comparatively low humidity (36%) for better and early sprout of bud that condition received during May month. While, there was high rainfall and relative humidity recorded during July budding and that time all buds were in sprouting phase. Therefore, there was poor availability of solid and plumpy buds for budding operation. Moreover, due to high rainfall and relative humidity rotting took placed at bud union in July budded plants which might be damaged the bud sprout resulting less success of budding (Fig. 1). Shah *et al.* (2017) also propounded similar cause of reduced budding success with the advancement of season due to low temperature and reduced sap flow in rootstock, stressed callus formation and suppressed activity of hydrolyzing enzymes that favours inadequate mobilization of reserve food material. The results are in close confirmity with the findings of Chovatia and Singh (1996) in *lasoda* with highest budding success (96.70%) during May month; Kumar *et al.* (2017) in guava and they had reported earliest bud sprout and the highest success (28 days and 76.67 %) from May budding followed by June (30.20 days and 73.33 %) and longest time and the lowest success (36.80 days and 56.67 %) from July budded plants of guava. The contrasting results on budding success were reported by Nath *et al.* (2000); Singh *et al.* (2003); Meghwal (2007) in *lasoda* and by Kaur and Kaur (2018) in Jamun. They found the highest bud take success during July and August months. Similarly, bud sprout completion period was also found shortest (12 days) in May budding and longest in July budding (23.33 days). Baloda *et al.* (2016) reported longest period for bud sprouting, *i.e.*, 33.8 days during July month in jamun. The minimum budding success and longest time taken for bud to sprout during July month may be probably caused due to low temperature and inadequate cell sap flow from buds as well as rootstock (Kumar *et al.,* 2017). Similar trends was also noted with success rate of budded plants survival per cent (Table 5) and it was highest in May (82.22%) followed by June (60%) and lowest in July (35.55%) budded plants. The results of the present study, is in confirmation with the findings of Dixit *et al.* (2019) in guava and Baloda *et al.* (2016) in Jamun. This higher success of budding in May month can possibly be attributed to the firmness of bud held with the stem of root stock without any interference from the plant tissue (Shah *et al.,* 2017 and Dixit *et al.,* 2019). The data revealed that there was significant decrease in sprout length with budding. Sprout length and diameter after 90 days of budding were time highest (52.81 cm and 5.02 mm) in May budded plants followed by June (40.65 cm and 4.07 mm) and lowest (36.91 cm and 3.56 mm) in July month budded plants, respectively. At 90 days after budding, the maximum plant height was measured in May (70.64 cm) budding followed by June (58.08 cm) and it was lowest in July month (52.65 cm).

The average number of leaves per plant was observed maximum in May (11.87) budding followed by June (10.27) and minimum in July (8.67) budded plants. The findings are in close confirmity with Kumar *et al.* (2017); Kaur and Kaur (2018) in case of guava and jamun, on the budded plants during May, June and July months. Meanwhile, May month budded plants required least period (85-90 days) for field planting followed by June month (110-120 days) and longest period (130-150 days) in July budded plants. The results of present investigation clearly indicate that the plants were ready for transplanting within 85-90 days when budding was done in May, whereas it took 110-120 days in June and maximum time was taken (130-150 days) when budding was done in July (Table 5). Singh *et al.* (2019) also found similar results during mid-June month with patch budding and reported better success rate with respect to number of sprouts, survival percentage, shoot length and leaf area in guava. Seed, rootstocks and planting material standards (Table 6) of *lasoda* require some prerequisites for production of quality planting material such as ripened fresh fruits should have diameter > 1.5 cm with > 6 g weight and can be kept for a week otherwise germination reduces drastically, no germination after 20 days of storage at ambient temperature; seed germination should be more than 60% and completed within 25 days of sowing; during shifting of seedlings in polybags require minimum 25-30 days period having height of about 5-6 cm; seedlings should attain buddable stage in about 5-6 months from seed sowing with height of 35-40 cm and girth 0.6-0.8 cm; age of rootstock should be 9-12 months old with 8-10 mm girth and bud union on rootstock at 15-20 cm above ground level; budding (patch budding) should be done during May-June months taking scion from new growth of the current season of mother plant; for better success rate the size of patch should be about 2.0 x 1.5 cm on the rootstock, similar size scion bud stick from middle portion of current season's growth should be fixed for budding operation; after successful budding, plants with sprout length ≥ 50 cm and diameter ≥ 0.5 cm should be good for planting at 90 days of budding with total plant height about 65-70 cm; and plants should be ready within 90 days of (May month) budding so that same season field planting can be possible (Table 6).

Lasoda is a cross pollinated fruit crop; thus, seedling progenies can help in creating genetic diversity that can be used in future fruit breeding programmes. Appropriate stage of fruit collection, it's size, sowing time, media composition and growing conditions required for better germination were identified in the present study. Furthermore, optimum stage of seedling growth for shifting and transplanting was also determined in form of seedling standards. These standards were developed which can help in quality production of large number of seedling plants from improved genotypes. Developed planting material standards through patch budding would be helpful in order to conserve the elite germplasm, mass multiplication of genuine planting material for commercial orcharding and taking up systematic studies in *lasoda*. These standards were developed after series of experimentations in hot arid climate; therefore there will be minor variations possible when repeated in other edapho-climatic conditions.

Acknowledgments

The authors are thankful to the Director of the institute and Head, Division of Crop Improvement, ICAR – Central Institute for Arid Horticulture, Bikaner for support and encouragement to perform present study.

Add-on Information

Authors' contribution: K. Kumar: Carried out the study, analyzed data and prepared the manuscript; **D.K. Sarolia:** Carried out the study, analyzed data and prepared the manuscript;

P.L. Saroj: Planning of experiment and improvement of manuscript; **D.K Samadia:** Formulation of technical standards and manuscript correction; **D. Singh:** Guidance and formulation of technical standards.

Research content: The research content of manuscript is original and has not been published elsewhere.

Ethical approval: Not applicable.

Conflict of interest: The authors declare there is no conflict of interest.

Data from other sources: Not applicable.

Consent to publish: All authors agree to publish the paper in *Journal of Environmental Biology*.

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