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Standardisation of propagation techniques of *Tribulus terristris* Linn: An important medicinal species of Western Himalayas

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Abstract
The demand for medicinal plants has increased tremendously at Global level, which causes huge pressure on wild collection. The unscientific and unsystematic collection from wild "adds fuel to the fire." As the consequence, the rates of exploitation may exceed those of natural regeneration. Also, the natural habitats are fast depleting. Therefore, it is need of the hour to standardize the propagation techniques of important medicinal plants. *Tribulus terrestris*, an economically important medicinal plant species, also known as puncture vine, is a perennial hardy plant species, but it also grows as an annual in colder climates. In this Research, *Tribulus terristris* was subjected to moist sand stratification (S_1 = 0 days, S_2 = 15 days, S_3 = 25 days and S_4 = 35 days) to give best treatment for better seed germination of the species. In order to work out best sowing media for better growth and survival, three different sowing media were used (Sand, Sand and Soil, Sand, Soil and FYM). The seedlings were also tried in beds, paper bags and hanging pots to study the growth parameters of the species.

Keywords: demand, propagation, puncture vine, stratification, treatment

Introduction
Tribulus terrestris is an annual plant in the caltrop family (Zygophyllaceae) widely distributed around the world. It is adapted to grow in dry climate locations in which few other plants can survive. It is native to warm temperate and tropical regions in southern Eurasia and Africa. *Tribulus terrestris* is widely known as a noxious weed because of its small woody fruit – the bur – having long sharp and strong spines which easily penetrate surfaces such as the bare feet or thin shoes of crop workers and other pedestrians, the rubber of bicycle tires, and the mouths and skin of grazing animals. *Tribulus terrestris*, also known as puncture vine, is a perennial hardy plant species, but it also grows as an annual in colder climates. Tribulus has been cultivated as an herbal remedy and is used by Chinese medicine practitioners to treat a number of ailments. Once established, Tribulus needs little to no attention to thrive, and it can quickly spread across a garden, overtaking other plants. In India, the species is largely found across North-Western Himalayan region.

Tribulus terrestris occurs on almost any soil type but grows best in dry, loose, sandy soils and prospers near sand dunes or loose blown soil around field margins. It also grows in heavier soils, especially when these are fertile or moist, and on compacted soils such as those found along roadsides (Holm *et al.*, 1977). Germination of *T. terrestris* starts in spring or during warm weather soon after the first rains of the season. (Misra 1962) [19] reported that this occurs within 5 to 7 days of late spring or early summer showers in India. A succession of germination episodes occurs throughout the rainy season, making control difficult. The majority of seed germination occurs in the upper 4 cm of loam soils (Goeden and Ricker, 1973) [9], declining with depth and heaviness of soils. *T. terrestris* seeds can also germinate on the soil surface. Seeds can be dormant for 3-6 years, this period being extended by deep burial. The position of the seed within the carpel (burr segment) influences germination: seeds nearest the stylar end of the 2-, 3- and 4-seeded carpels tend to germinate first (Goeden and Ricker, 1973) [9].

The survival of *Tribulus terrestris* in dry conditions is attributed to its deep roots (2 m or more) and large root volume which is capable of efficiently tapping available soil moisture. Davis *et al.* (1965) [8] found that *Tribulus terrestris* can have a root volume of 5.3 m^3 and is able to extract 14.1 kg of water per plant in excess of the rainfall received. It is also a very

efficient user of water; 96 kg of water is required to produce 1 kg of dry matter compared with lucerne (alfalfa) and sorghum which require 840 and 300 kg, respectively (Davis and Wiese, 1964) [7]. Since its water requirements are low, it can survive droughts, conversely, excess moisture can restrict its growth (Davis *et al.*, 1965) [8]. Nodules containing bacteria (Bradyrhizobium) and cyanobacteria (Newmania karachiensis) can be found on the roots of *T. terrestris* (Mahmood *et al.*, 1998) [18]. The life cycle of *T. terrestris* plants is terminated by frosts but, in tropical climates, plants can exhibit a perennial habit.

In India, *Tribulus terrestris* is used in folk medicine as a tonic and diuretic, and for the treatment of painful urination, calculous affections and Bright's disease. Leaves are rich in calcium but poor in iron, providing a cheap supplement to rice diets (Ambusta, 1986) [1]. There are indications that *Tribulus terrestris* may have potential as a treatment for urinary stones (Al Ali *et al.*, 2003), Parkinson's disease (Badmaev, 2002) [3], malignant melanoma (Bedir and Khan, 2000) [5], liver and eye diseases (Li *et al.*, 1998) [16] and benign prostatic hyperplasia (Lokesh *et al.*, 2001) [17]. There is some evidence that *Tribulus terrestris* can improve male sexual function (Gauthaman *et al.*, 2002) [10] and the performance of athletes (Krcik, 2001) [15]. Care should be exercised in the use of *Tribulus terrestris* because it contains poisons that can harm man. Comprehensive details of the medicinal value of *Tribulus terrestris* are reviewed by Ross (2001) [24].

Extracts of *Tribulus terrestris* have been found to control or suppress the growth of Spodoptera litura (Prasad *et al.*, 1993) [21], Dysdercus cingulatus (Gunasekaran and Chelliah, 1985) [11], Meloidogyne javanica (Khurma and Singh, 1997) [14] and *Meloidogyne incognita* (Singh *et al.*, 1991) [25], Antimicrobial activity has been found against Staphylococcus aureus, Escherichia coli and Candida albicans (Jit *et al.* 1986) [13]. Leaf treatment of mulberry with aqueous extracts of *T. terrestris* and *Psoralea corylifolia* during the third larval instar of silkmoth (*Bombyx mori*) suppressed grasserie, caused by a nuclear polyhedrosis virus, by 60% (Sivaprakasam and Rabindra, 1997) [26]. Oil extracted from the seeds of *Tribulus terrestris* has a synergistic effect when mixed with deltamethrin (Awwad *et al.*, 1987) [2].

Tribulus terrestris has been cultivated in India to reduce soil erosion by wind and water and loss of soil moisture. It has also been used to improve soil texture and water holding capacity in wastelands (Brajeshwar, 2002) [6]. The demand for medicinal plants has increased tremendously at Global level, which causes huge pressure on wild collection. The unscientific and unsystematic collection from wild “adds fuel to the fire.” As the consequence, the rates of exploitation may exceed those of natural regeneration. Also, the natural habitats are fast depleting (Pushpangadan and Nair 2001) [22]. The review of literature indicated that various studies on medicinal plants were focused on seed germination stimulation by chemical treatments, chilling treatments and a few testing the effect of temperature regimes (Rawat *et al.*, 2004) [23]. The scientific cultivation of *Tribulus terrestris Linn* has not been done yet inspite of its immense medicinal properties. Therefore, efforts were done to standardize its propagation protocol at regional level to encourage its cultivation with following objectives:

1. Standardisation of propagation techniques of *Tribulus terristris* Linn.
2. Effect of Stratification, Sowing media and Container type on growth parameters.

Materials and Methods

Detailed Technical Programme

Species: *Tribulus terristris Linn*.

Replication: Three replications and 40 seeds per treatments

Treatment details

1. Moist sand stratification (Days)

S1: 0 days
S2: 15 days
S3: 25 days
S4: 35 days

2. Sowing media

M1: Sand
M2: Sand and Soil
M3: Sand, Soil and FYM

3. Propagation details

A1: Beds
A2: Paper bags
A3: Hanging pots

Statistical design and Data analysis

RBD Design

The data will be analyzed statistically for analysis of variance (ANOVA; $P< 0.05$), least significant difference (Snedecor and Cochran, 1967), mean and standard error using MS-Excel programme 2000.

Location: Nursery, Division of Forest products and Utilization, Faculty of Forestry, SKUAST-Kashmir, Jammu and Kashmir, India.

Observations

Germination percent and Germination capacity will be calculated by using, MGT=S(fx)/ Sx, where x is the number of newly germinated seeds on each day, and f is the number of days after seeds were set to germinate (Nichols and Heydecker, 1968).

Plant height, collar diameter, number of branches, seed weight per plant and plant biomass.

Results and Discussion

Tribulus terristris native to Himalayan region is one of the most popular medicinal plant species around the world. The roots have immense medicinal uses, particularly for increasing testosterone levels in men. The species is listed in prioritirized medicinal plants by National medicinal plant board of the country.

The seeds of *Tribulus terristris* were collected in August, 2019 from three districts of Kashmir region of Jammu and Kashmir State (Ganderbal, Baramulla and Bandipora) and were subjected to moist sand stratification under different stratification treatments. The observations recorded after different stratification treatments are shown in table 1.

$$\text{Germination Percent} = \frac{\text{Total No. of Seeds germinated}}{\text{Total No. of Seeds Sown in all Replicates}} \times 100$$

$$\text{Germination Capacity} = \frac{\text{Total No.of Seeds germinated+Seeds found viable after cutting}}{\text{Total No.of Seeds Sown in all Replicates}} \times 100$$

Table 1: Germination parameters of *Tribulus terristris under Laboratory conditions*

Stratification (days)	Total No. of Seeds Germinated	No. of seeds found viable after cutting	Germination percent (%)	Germination capacity
0	8	15	20.0	57.5
15	12	18	30.0	75.0
25	20	15	50.0	87.5
35	16	20	40.0	90.0

The perusal of Table 1 reveals that highest No. of seeds were germinated in treatment S_3 (25 days Stratification) 20 and lowest Number. In control (0 days Stratification) 8.
After Germination the seedlings were planted in Nursery bed, hanging pots and paper bags in three different media sand alone, sand and soil and sand, soil and FYM. The observations of growth parameters (plant height, color diameter, no. of branches per plant, seed weight per plant and biomass per plant) were recorded in October, 2020.

Table 2: Effect of moist sand stratification, sowing media and container type on height of *Tribulus terristris*

	S_1			Sub Mean	S_2			Sub Mean	S_3			Sub Mean	S_4			Sub Mean	Mean
	A_1	A_2	A_3		A_1	A_2	A_3		A_1	A_2	A_3		A_1	A_2	A_3		
M_1	41.083	41.507	41.600	41.396	43.967	44.117	44.700	44.261	49.583	50.500	51.150	50.411	52.700	52.533	53.367	52.866	47.233
M_2	42.250	42.800	42.767	42.605	45.350	45.750	46.500	45.866	51.833	52.650	52.883	52.455	53.183	53.267	54.100	53.516	48.610
M_3	43.017	43.417	43.700	43.378	47.050	48.667	49.500	48.405	51.833	53.817	54.533	53.394	52.967	52.667	52.800	52.811	49.497
Mean	42.116	42.574	42.689	42.459	45.455	46.178	46.900	46.177	51.083	52.322	52.855	52.086	52.950	52.822	53.422	53.064	48.447

($P \leq 0.05$)
- Stratification (S): 0.236
- Sowing Media (M): 0.205
- Container (A): 0.205
- S×A: 0.409
- S×M: 0.409
- A×M: N.S
- S×A×M: 0.709

The perusal of data in table 2 reveals all the treatments and interactions were found significantly affect plant height except the interaction between sowing media and container type (A×M). The maximum height 54.533 cm was recorded when seeds were subjected to 25 days stratification (S_3) sown in hanging pots (A_3) and using sand, soil and FYM in the ratio of 1:1:1 as sowing media (M_3). The minimum height 41.083 cm was recorded when seeds were not stratified (S_1) sown in sand only (M_1) in beds (A_1). The reason for greater height in hanging pots using sand, soil and FYM in the ratio of 1:1:1 is that seedlings get enough space in hanging pots as the branches of *Tribulus terristris* are drooping, they grow upto maximum without touching anywhere as compared to when seedlings were grown in beds where seedlings after touching ground at different place hampers its growth. The maximum height in S_3 (25 days) Stratification is in consistent with the results shown by Reza *et al.*, 2015, for *Rheum khorasanicum*. The maximum height of the seedlings in sand, soil and FYM in the ratio of 1:1:1 is due to the presence of abundant nutrients in the media.

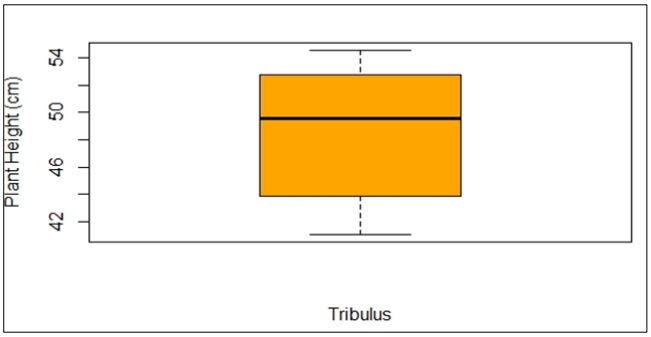


Table 3: Effect of Moist sand Stratification, Sowing Media and Container type on Collar diameter of *Tribulus terristris*

	S_1			Sub Mean	S_2			Sub Mean	S_3			Sub Mean	S_3			Sub Mean	Mean
	A_1	A_2	A_3		A_1	A_2	A_3		A_1	A_2	A_3		A_1	A_2	A_3		
M_1	2.653	2.657	2.653	2.654	2.667	2.673	2.680	2.673	2.697	2.700	2.710	2.702	2.713	2.677	2.707	2.699	2.682
M_2	2.657	2.663	2.667	2.662	2.677	2.683	2.683	2.681	2.713	2.727	2.763	2.734	2.683	2.727	2.723	2.711	2.697
M_3	2.667	2.443	2.670	2.593	2.687	2.693	2.693	2.691	2.797	2.803	2.873	2.824	2.690	2.717	2.693	2.700	2.702
Mean	2.659	2.587	2.663	2.636	2.677	2.683	2.685	2.681	2.735	2.743	2.782	2.753	2.695	2.707	2.707	2.703	2.693

($P \leq 0.05$)
- Stratification (S): N.S
- Sowing Media (M): N.S
- Container (A): N.S
- S×A: N.S
- S×M: N.S
- A×M: N.S
- S×A×M: N.S

The perusal of data in table 3 reveals that all the treatments and interactions were found non-significant w.r.t collar diameter of *tribulus terristris*. The maximum collar diameter 2.873 mm was recorded when seeds were subjected to 25 days stratification (S_3) sown in hanging pots (A_3) and using sand, soil and FYM in the ratio of 1:1:1 as sowing media (M_3). The minimum collar diameter 2.443mm was recorded when seeds were not stratified (S_1) sown in sand only (M_3) in paper bags (A_2). The reason for greater collar diameter in hanging pots using sand, soil and FYM in the ratio of 1:1:1 is that seedlings get enough nutrients, as one part of FYM increases porosity and nutrient availability of media. The maximum collar diameter in S_3 (25 days) Stratification is in consistent with the results shown by Sofi *et al.*, 2020 [27], for *Betula utilis*. The maximum height of the seedlings in sand, soil and FYM in the ratio of 1:1:1 is due to the presence of abundant nutrients in the media.

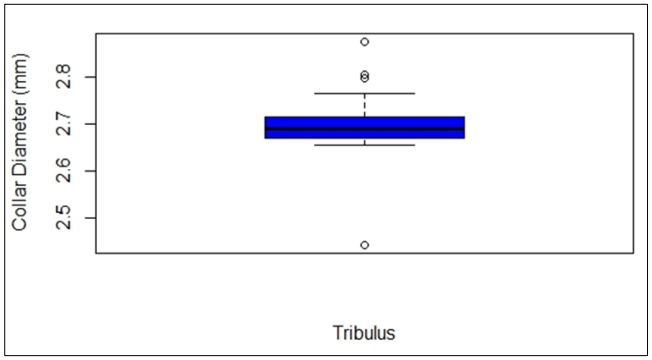


Table 4: Effect of Moist sand Stratification, Sowing Media and Container type on Plant biomass of *Tribulus terristris*

	S_1			Sub Mean	S_2			Sub Mean	S_3			Sub Mean	S_3			Sub Mean	Mean
	A_1	A_2	A_3		A_1	A_2	A_3		A_1	A_2	A_3		A_1	A_2	A_3		
M_1	45.567	45.800	46.567	45.978	47.217	47.267	48.333	48.721	48.200	50.950	52.750	50.633	52.483	52.783	52.450	52.572	49.266
M_2	46.233	46.817	46.917	46.655	46.900	47.517	49.700	50.839	52.583	53.450	55.467	53.833	50.933	49.783	52.883	51.199	50.106
M_3	47.317	47.383	48.317	47.672	48.583	48.650	50.333	50.938	54.317	53.717	56.033	54.689	48.817	48.700	49.183	48.900	50.221
Mean	46.372	46.666	47.267	46.768	47.566	47.811	49.455	50.166	51.700	52.705	54.750	53.051	50.744	50.422	51.505	50.890	49.864

(P≤0.05)
- Stratification (S): 0.265
- Sowing Media (M): 0.230
- Container (A): 0.230
- S×A: 0.459
- S×M: 0.459
- A×M: 0.398
- S×A×M: 0.796

The perusal of data in table 4 reveals that all the treatments and interactions were found significantly affect plant biomass of *Tribulus terristris*. The maximum Plant biomass 56.033 cm was recorded when seeds were subjected to 25 days stratification (S_3) sown in hanging pots (A_3) and using sand, soil and FYM in the ratio of 1:1:1 as sowing media (M_3). The minimum plant biomass 48.317 cm was recorded when seeds were not stratified (S_1) sown in sand only (M_1) in beds (A_1). The reason for maximum biomass in hanging pots using sand, soil and FYM in the ratio of 1:1:1 is that seedlings get enough space in hanging pots as the branches of *Tribulus terristris* are drooping, they grow upto maximum as compared to when seedlings were grown in beds. The maximum plant biomass in S_3 (25 days) Stratification is in consistent with the results shown by Sofi *et al.*, 2020 [27], for *Betula utilis*. The maximum plant biomass of the seedlings in sand, soil and FYM in the ratio of 1:1:1 is due to the presence of abundant nutrients in the media.

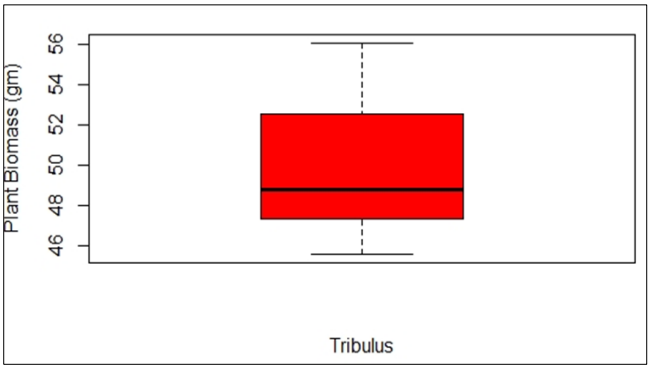


Table 5: Effect of Moist sand Stratification, Sowing Media and Container type on Number of branches per Plant of *Tribulus terristris*

	S_1			Sub Mean	S_2			Sub Mean	S_3			Sub Mean	S_3			Sub Mean	Mean
	A_1	A_2	A_3		A_1	A_2	A_3		A_1	A_2	A_3		A_1	A_2	A_3		
M_1	4.333	4.667	4.333	4.444	4.000	4.000	3.667	3.889	4.667	4.667	5.000	4.778	4.333	5.000	4.333	4.555	4.416
M_2	3.667	4.667	4.667	4.333	4.333	4.667	4.667	4.555	4.000	4.667	5.667	4.778	4.000	3.667	3.667	3.778	4.361
M_3	4.000	4.667	4.333	4.333	4.333	4.667	4.000	4.333	4.333	6.333	7.333	5.999	3.667	3.333	3.000	3.333	4.499
Mean	4.000	4.667	4.444	4.370	4.222	4.444	4.111	4.259	4.333	5.222	6.000	5.185	4.000	4.000	3.666	3.888	4.425

(P≤0.05)
- Stratification (S): 0.258
- Sowing Media (M): 0.223
- Container (A): N.S
- S×A: 0.446
- S×M: 0.446
- A×M: N.S
- S×A×M: 0.773

The perusal of data in table 5 reveals that all the treatments and interactions were found significantly affect number of branches of plant except the interaction between sowing media and container type (A×M). The maximum number of branches 7.333 were recorded when seeds were subjected to 25 days stratification (S_3) sown in hanging pots (A_3) and using sand, soil and FYM in the ratio of 1:1:1 as sowing media (M_3). The minimum number of branches 4.333 were recorded when seeds were not stratified (S_1) sown in sand only (M_1) in beds (A_1). The reason for higher number of branches in hanging pots using sand, soil and FYM in the ratio of 1:1:1 is that seedlings get enough space in hanging pots as the branches of *Tribulus terristris* are drooping, they grow into different directions without touching ground. The maximum number of branches in S_3 (25 days) Stratification is in consistent with the results shown by pendota *et al.*, 2016 [20], for *Boscia albitrunca*. The maximum number of branches of the seedlings in sand, soil and FYM in the ratio of 1:1:1 is due to the presence of abundant nutrients in the media.

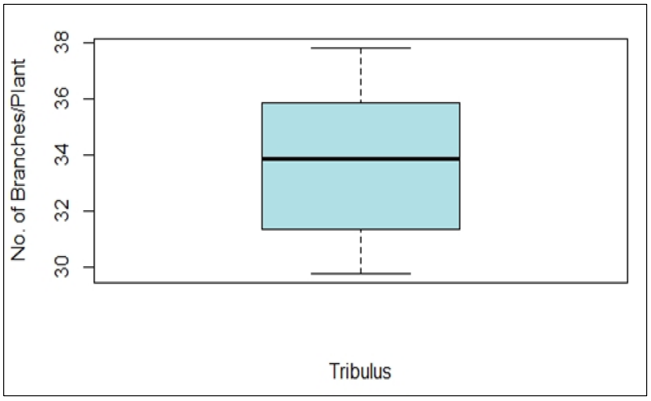


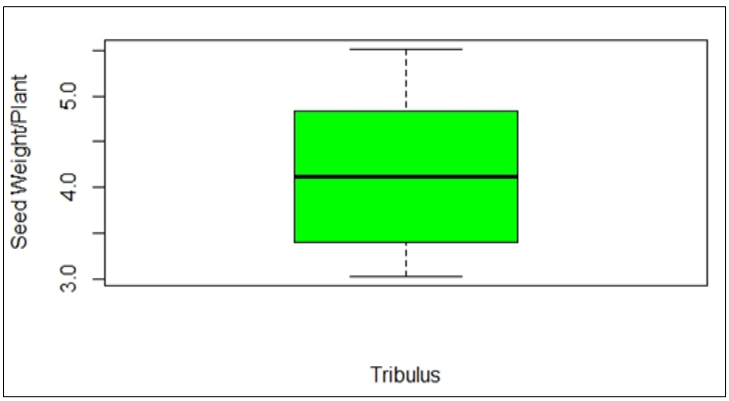
Table 6: Effect of Moist sand Stratification, Sowing Media and Container type on Seed weight per Plant of *Tribulus terristris*

	S_1			**Sub Mean**	**S_2**			**Sub Mean**	**S_3**			**Sub Mean**	**S_3**			**Sub Mean**	**Mean**
	A_1	**A_2**	**A_3**		**A_1**	**A_2**	**A_3**		**A_1**	**A_2**	**A_3**		**A_1**	**A_2**	**A_3**		
M_1	3.037	3.040	3.123	3.066	3.400	3.450	3.610	3.486	4.433	4.633	4.823	4.629	4.983	4.917	4.850	4.916	4.024
M_2	3.087	3.137	3.233	3.152	3.747	3.783	3.817	3.782	4.943	5.100	5.167	5.070	4.610	4.500	4.450	4.520	4.131
M_3	3.243	3.260	3.400	3.301	3.897	4.033	4.140	4.023	5.390	5.493	5.507	5.463	4.283	4.217	4.110	4.203	4.247
Mean	3.122	3.145	3.252	3.173	3.681	3.755	3.855	3.764	4.922	5.075	5.165	5.054	4.625	4.544	4.470	4.546	4.134

(P≤0.05)

- Stratification (S): 0.029
- Sowing Media (M): 0.025
- Container (A): 0.025
- S×A: 0.050
- S×M: 0.050
- A×M: N.S
- S×A×M: 0.087

The perusal of data in table 6 reveals that all the treatments and interactions were found significantly affect seed weight per plant except the interaction between sowing media and container type (A×M). The maximum seed weight per plant 5.507 g was recorded when seeds were subjected to 25 days stratification (S_3) sown in hanging pots (A_3) and using sand, soil and FYM in the ratio of 1:1:1 as sowing media (M_3). The minimum seed weight per plant 3.037 g was recorded when seeds were not stratified (S_1) sown in sand only (M_1) in beds (A_1). The reason for higher seed weight per plant in hanging pots using sand, soil and FYM in the ratio of 1:1:1 is that seedlings get enough space in hanging pots as the branches of *Tribulus terristris* are drooping; they grow into different directions without touching ground, hence producing greater quantity of seeds per plant. The maximum seed weight per plant in S_3 (25 days) Stratification is in consistent with the results shown by pendota *et al.*, 2016 [20], for *Boscia albitrunca*. The maximum seed weight per plant in sand, soil and FYM in the ratio of 1:1:1 is due to the presence of abundant nutrients in the media.



Tribulus terristris in Paper bags

Tribulus terristris under Nursery Bed

Tribulus terristris in Hanging Pots

Seeds of *Tribulus terristris*

Conclusion

Tribulus terristris can be cultivated as cash crop subjected to stratification of seeds. The moist sand stratification of 25 days was found a better option to germinate seeds naturally. The seedlings can be grown well in hanging pots using sowing mixture of sand, soil and FYM.

References

1. Ambusta SSP. The Useful Plants of India. New Delhi, India: Publications and Information Directorate, Council of Scientific and Industrial Research 1986.
2. Awwad SD, Al-Mallah NM, Al-Sharok M, Al-Jamel SK. Synergistic effect of some oils of weed seeds on synthetic pyrethroids and organophosphorus insecticides. Arab Journal of Plant Protection 1987;5(2):59-62.
3. Badmaev V. The evolving approach to Parkinson's disease. Nutra Cos 2002;1(4):14-16; 18.
4. Reza D, Mohammad RH, Vahedah N. Effects of moist stratification, GA_3 and seed age on seed germination of *Rheum khorasanicum* B. Baradaran & A. Jafari. Journal of Applied Research on Medicinal and Aromatic Plants 2015;2(4):168-173.
5. Bedir E, Khan IA. New steroidal glycosides from the fruits of *Tribulus terrestris*. Journal of Natural Products 2000;63(12):1699-1701.
6. Brajeshwar. Gokshura. Wastelands News 2002;17(2):46.
7. Davis R, Wiese A. Weed root growth pattern in the field. Proceedings of the 17th Southern Weed Conference. Knoxville, USA: University of Tennessee at Knoxville 1964, 367-368.
8. Davis R, Wiese A, Pafford J. Root moisture extraction profiles of various weeds. Weeds 1965;13:98-100.
9. Goeden RD, Ricker DW. A soil profile analysis for puncturevine fruit and seed. Weed Science 1973;21:504-507.
10. Gauthaman K, Adaikan PG, Prasad RNV. Aphrodisiac properties of *Tribulus terrestris* extract (Protodioscin) in normal and castrated rats. Life Sciences 2002;71(12):1385-1396.
11. Gunasekaran K, Chelliah S. Juvenile hormone effect of *Tribulus terrestris* L. and *Parthenium hysterophorus* L. on Dysdercus cingulatus F. In: Regupathy A, Jayaraj S, eds. Behavioural and Physiological Approaches in Pest Management. Coimbatore, India: Tamil Nadu Agricultural University 1985, 123-125.
12. Holm LG, Pancho JV, Herberger JP, Plucknett DL. A geographical atlas of world weeds. New York, USA: John Wiley and Sons 1979, 391.
13. Jit Shekhawat S, Grover SS, Nag TN. Screening of some plants of Zygophyllaceae for their antimicrobial activity. Acta Botanica Indica 1986;14(1):45-47; 7 ref.
14. Khurma UR, Archana S. Nematicidal potential of seed extracts: *in vitro* effects on juvenile mortality and egg hatch of *Meloidogyne incognita* and *M. javanica*. Nematologia Mediterranea 1997;25(1):49-54.
15. Krcik JA. Performance-enhancing substances: what athletes are using. Clevel and Clinic Journal of Medicine 2001;68(4):283-302.
16. Li JX, Shi Q, Xiong QB, Prasain JK, Tezuka Y, Hareyama T *et al.* Tribulusamide A and B, new hepatoprotective lignanamides from the fruits of *Tribulus terrestris*: indications of cytoprotective activity in murine hepatocyte culture. Planta Medica 1998;64(7):628-631.
17. Lokesh U, Tripathi K, Kulkarni KS, Upadhyay L. A study of Prostane in the treatment of benign prostatic hyperplasia. Phytotherapy Research 2001;15(5):411-415.
18. Mahmood Athar A, Malik M, Mirza KA, Ladha MS, JK. Cyanobacterial root nodules in *Tribulus terrestris* L. (Zygophyllaceae). Nitrogen fixation with non-legumes. Proceedings of the 7th International Symposium on Nitrogen Fixation with Non-legumes, Faisalabad, Pakistan, 16-21 October 1998-1996, 345-350.
19. Misra D. *Tribulus terrestris* weed in arid zone farming. Indian Journal of Agronomy 1962;7:136-141.
20. Pendota SC, Kulkarni MG, Staden JC. Germination, seedling growth requirements and antimicrobial properties of *Boscia albitrunca*: A keystone species in arid southern Africa. South African Journal of Botany

2016;104:105-111.
21. Prasad VD, Jayaraj S, Rabindra RJ, Reddy GPV. Studies on the interaction of certain botanicals and nuclear polyhedrosis virus against tobacco caterpillar, Spodoptera litura F. Botanical pesticides in integrated pest management. Rajahmundry, India: Indian Society of Tobacco Science 1993, 190-196.
22. Pushpangadan P, Nair K. Future of systematics and biodiversity research in India: Need for a National Consortium and National Agenda for systematic biology research. Current Science 2001;(80):5.
23. Rawat A, Kumar R, Bandana B, Pradeep R. Nanotechnology in Agriculture- A Review. International Journal of Current Microbiology and Applied Sciences 2004;7(8):969-978.
24. Ross IA. Medicinal plants of the world. Volume 2. Chemical constituents, traditional and modern medicinal uses. Totowa, USA: Humana Press 2001, 487.
25. Singh RP, Tomar SS, Devakumar C, Goswami BK, Saxena DB. Nematicidal efficacy of some essential oils against *Meloidogyne incognita*. Indian Perfumer 1991;35(1):35-37; 3 ref.
26. Sivaprakasam N, Rabindra RJ. Integrated grasserie management in silkworm. Insect Environment 1997;3(1):12.
27. Sofi PA, Masoodi TH, Pala NA, Megna R. Influence of seed source and stratification on germination and growth of Betula utilis D. Don under temperate conditions in Kashmir Himalaya. Indian Forester 2020;146(6):532-537.