

Cultivation and population status of Ephedra (*Ephedra gerardiana* Wall. Ex Stapf) critically endangered medicinal plant for the conservation in cold desert of Ladakh, India

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Abstract

Ephedra gerardiana is critically endangered and one of the most important medicinal plant of Trans-Himalaya of Ladakh. It is majorly used medicinal plant of Ayurveda, Sowa-Rigpa, Unani, Homeopathy, Siddha, Allopathy and other traditional medical systems, hence it is very important to understand its density, and cultivation technique for effective sustainable collection, conservation and utilization. The three valleys of Ladakh viz., Indus, Suru and Nubra valleys were analysed for the population census where the density of the species were ranges between 0.2-3.85 ind/m² revealed the degree of threat of the species. Germplasm collected from different locations were studied for cultivation packages and practices in three conditions such as polycarbonate greenhouse, trench greenhouse and open field as controlled. We observed that the highest germination percentage (82.67±3.79) and survivability percentage (75.67±4.04) in polycarbonate greenhouse followed by trench greenhouse (58.00±2.00) (50.67±1.53) after 30 minutes of hot water treatment, sown in farm yard manure (FYM), clean sand, clay soil and sandy soil in the ration of 2:1:1:1. Morphological characters such as plant height (7.00±1.00), number of leaves (31.67±1.53) and root length (18.33±1.53) were also observed highest in polycarbonate greenhouse. Owing to its potential uses in the region and other part of the world make the species under threat. Results provide the comprehensive information about this valuable species for cultivation, ethnobotany, and population census for conservation of *E. gerardiana* critically endangered medicinal plant of Himalaya.

Introduction

The distribution pattern of *E. gerardiana* in the Himalayan region considered as critically endangered using IUCN criteria (Samant and Pant 2006) and endangered in Trans-Himalayan cold desert of Ladakh and Lahaul-Spiti (Chaurasia and Gurmet 2003). It is locally known as Tsepat, and mTshe-IDum in Sowa-Rigpa (Gurmet and Rath 2020) and popular trade name is Somlata. Himalayan region medicinal plants have occupied an important values spiritually, culturally, and health benefits of the peoples. More than 34% of total plant wealth have known to have medicinal value (Ved 2008). The genus *Ephedra* belonging to member of *Ephedraceae*, is a group of plants that inhabit temperate regions in Asia, Eurasia, Northern Africa, South-western North America, and western South America. Due to its xerophytic characters, it is a drought and frost resistant. It is represented by 50-65 species of shrubs, rarely small trees (Stevenson 1993; Sharma and Uniyal 2008; Sharma et al. 2010). Three species were reported from Ladakh including *E. gerardiana*, *E. intermedia* and *E. regeliana* (Dvorsky et al. 2018). In India, its distribution extends from Sikkim in Eastern Himalaya to North-West in Uttarakhand, Ladakh, Himachal Pradesh, and Jammu & Kashmir. Genus *Ephedra* have eleven species that distributed in the Indian sub-continent, mostly in higher elevations of Himalaya preferring alkaline soils. Different species that occur in various regions of country are markedly different from each other in term of their habitat preferences that promote diversity within the genus (Sharma and Uniyal 2008; Sharma et al. 2010). The drug Ephedrine and many active compounds such as ephedrine, pseudoephedrine, norephedrine, norpseudoephedrine, methyl ephedrine, methyl pseudoephedrine, alkaloids, phenoles, terpenoids are obtained from the *E. gerardiana* and is one such important endangered medicinal plant. In trans-Himalaya of Ladakh the *E. gerardiana* is being used by local healers (Amchis) and ethnic people to cure various diseases such as chronic fever, wounds, tumours, discomfort in breathing, cough, sweating, urine obstructions (Gurmet and Stobgais 2016). The fruit and shoot is also used for the treatment of asthma, rheumatism and heart stimulant in Sowa-Rigpa by local healers (Amchis) of High altitude of Ladakh (Kunzes et al. 2012). The decoction of areal part is used against bronchial problems and liver disorders. It is also cure menstrual irregularities (Navchoo and Buth 1992). *E. gerardiana* is also used in Ayurveda, Unani, Siddha, Homeopathy Chinese medicines, folk medicine and other traditional medicines. Due to its resinous smell and taste it is used with tobacco after drying and making powder called Sotak, a pinch of which local people place under the tongue in Ladakh. Twigs used as a tooth brush (Bhattacharyya 1991). The *E. gerardiana* has been also used for other purposes by ethnic communities, where fruit is eaten in high altitude areas, whole plant used for fuel, aerial part is used for washing utensils and also used for religious purposes in cold desert (Samant and Lal 2019). Owing to its many fold medicinal properties and their folk uses, *E. gerardiana* is in high demand by pharmaceutical industries and traditional healers. Lack of suitable and effective conservation management, over exploitation, habitat degradation the genus is under brink of extension. For long-term conservation management of this genus, a better and comprehensive understanding of the species remains a top priority, for which detailed studies on its habitat ecology, biology, and agro-technology are not done so far (Samant and Lal 2019). *E. gerardiana* is an erect shrub of varying sizes, bears cylindrical, striated, often curved branches arising in whorls, dark green in colour. The internodes of branchlet measure 1-5 cm in length and the fruits are 1-3 mm in width are red in colour, sweet in taste and edible. The ovoid fruits contain 1-3 seeds covered by bracts. The rhizomes have large knobs. It is found scattered in the drier regions of temperate and alpine Himalayas from Kashmir to Sikkim at altitude range 2100-4800 m amsl (meter above mean sea level) and similar heights at Pangri (Chamba), Lahaul and Spiti, Chini and Kilba Kailash ranges of Kanawar (Kinnaur), Shali hills (Shimla), Kashmir and Ladakh. The habitat preference of the plant are sandy slopes, rocky slopes, sandy places and driers area of Himalayas. In this present study we are focusing on population census, ethnobotany, agro-technology for in-situ and ex-situ conservation in Ladakh region.

Materials And Methods

Temperature and lux intensity

The temperature (°C), relative humidity (%) were measured with the help of tinytag ultra-2 thermo hygrometer and light intensity with LX-101A luxmeter of the polycarbonate greenhouse, trench greenhouse and in open field conditions figure 1,2,3.

Documentation: To document the folk and medicinal uses and germplasm collection of medicinal plants: through literature survey was conducted followed by extensive field surveys were carried out during two different stages of plant i.e., flowering and seed stage in three valleys of Ladakh (Suru, Nubra and Indus). The field surveys were conducted in the month of July-October 2018. During field survey *E. gerardiana* was found only in 17 sites. Maximum time was spent with the tribal people of different age groups to understand the details about the uses of *Ephedra* in their day to day life and medicinal uses by Amchis (local healers). Semi-structured questionnaires, interviews and participatory reviews were used to elucidate information from the experienced persons (Amchis) using standard methods (Martin 1995). Information on local names of plants, and plant parts used for curing various ailments were recorded. Field visits were also planned with the elders and Amchis to ascertain the plants and also to obtain first-hand information on their distribution. The plants is collected for

identification and herbarium preparation following standard methods (Jain and Rao 1976). The voucher specimens are submitted to National Institute of Sowa-Rigpa Leh, Ladakh for future reference.

Population assessment of *Ephedra Gerardiana*:

The sites representing *E. Gerardiana* were selected along sites between 2742 to 4500 m amsl. A total of 17 sites namely Sanku (3146 m); Hunder (3165 m); Karceykhari (3492 m); Thangbo (3531 m); Sangra (3228 m); Damsna (3186 m); Achambur (3244 m); Panikhar (3391m); Parkachik (3498m); Thasgam (4127 m); Rangdum 4012 m) Gonpa (3764), Tangyar (4199 m); Aghyam (3241 m); Sakti (3519 m); Khalser (4054 m); Diskit (4019), selected to collect the information. Observations on altitude, habitat and their associated species were recorded Table 1.

Survey, sampling, identification and analysis of data

The field surveys and samplings were carried out in 2018-2019 within the selected sites. In each site a plot of 20x20m was laid. Species were sampled by randomly placed 20 quadrats of 1x1 m in each plot. The size and number of quadrat was determined following Misra (1968) and Kersaw (1973). For the collection of data from these quadrats and data analysis were done following standard ecological methods (Grieg-Smith 1957; Kersaw, 1973; Muller-Dombois and Ellenberge 1974; Dhar et al.1997). From each site, sample of each species were collected and identified with the help of floras and related research papers (Polunin and Stainton 1984; Kachroo et al. 1997; Chaurasia and Singh 1996; Chaurasia et al. 2008). Garmin, Global Positioning System (GPSMAP) 78s was used for recording altitudes.

$$\text{Density} = \frac{\text{Total number of individuals}}{\text{Total number of quadrat studied}}$$

$$\text{Frequency} = \frac{\text{Total number of quadrat of occurrence}}{\text{Total number of quadrat studied}} \times 100$$

Cultivation packages and practices:

All the collected germplasm/seed were kept in room temperature before sown at research field at Trans-Himalayan Herbal Garden of National Institute for Sowa-Rigpa, Leh, Ladakh. The agro-technology was standardized for nursery development and transplantation of species in the open field and in poly nursery bags for in-situ, ex-situ conservation.

Nurseries: The Nursery was raised in protective polycarbonate greenhouse and trench greenhouse and open field as controlled.

Bed preparations: The bed of 1x2 m (length x breadth) = 2m² was prepared in the different ratio by using Farm Yard Manure (FYM), clean sand, Clay soil and sandy soil 2:1:1:1, 1,2:1;1, 1:1:2:1, 1:1:1:2 respectively and an individual as controlled

Pre seed treatments: Freshly harvested seeds from the wild were treated by soaking in hot water maintaining at 40-70 °C for 30 and 10 minutes in water bath made LABSOUL INDIA.

Sowing of seeds: The 50 seeds per row were sowed at the depth of one centimetre with the distance of one cm seed to seed and 30 cm row to row in four replications in the month of March 2019.

Transplantation: The developed nurseries in the protected condition were transplanted in the month of June 2019 directly in open field (100 plants) figure 5 and in the poly nursery bags (100 plants) figure 6. After taking care in both the conditions the one year old poly nursery bags plants were again transplanted in open field in the month of March 2020 (100 plants) figure 7.

Data collection: Agro-morphological (qualitative and quantitative) parameters were recorded such as germination percentage, survivability, plant height (measuring scale in cm), number of leaf, root length (Measuring scale in cm). All data recorded were analysed with SPSS version 17.00, 2019.

Results

A total of one hundred thirty one sites were sampled. Out of which, *E. Gerardiana* was found in only 17 sites. The physical and vegetation characteristics of *E. Gerardiana* have been presented in table 1. In all the reported sites, *E. Gerardiana* showed density in between 0.2 -3.85 ind/m², whereas, *Artemisia* spp. showed maximum (5.7 ind/m²) density, followed by *Physochlaina praealta* (4.8 ind/m²), *Bergenia stracheyi* (3.45 ind/m²), *Heracleum pinnatum* (3.5 ind/m²), and *Lindelia stylosa* (2.0 ind/m²) Table 1.

In the questionnaire survey of the study area, we collected the information from 75% and 25% male and female respectively. Out of total informants, only 41% males and 31% females were well versed with the use of *E. Gerardiana* and they also know the potential sites of the targeted species where they used to visit

along with the researchers and tourists. According to the respondents, it was clear that the target species facing grave threat due to the over exploitation and illegal collection made by the local inhabitants and also by the outsiders.

In optimized cultivation packages and practices in Ladakh condition, we observed that the species can be cultivated by raising the nurseries with freshly harvested seeds treating with hot water for 30 minute and sown in the mixture of farm yard manure (FYM), clean sand, clay soil and sandy soil in different conditions. In polycarbonate greenhouse average annual temperature is maximum 32.22 ± 2.96 °C minimum 3.89 ± 1.61 °C, relative humidity maximum 68.24 ± 4.42 % , and light intensity was 49084.42 ± 7237.78 Lux were recorded, in polycarbonate greenhouse the germination percentage was (82.67 ± 3.79) %, survivability (89.00 ± 4.36) %, plant height (67.00 ± 1.00) cm, number of leaf (31.67 ± 1.53) and root length (18.33 ± 1.53) cm was recorded highest in 30 minute hot water treatment with FYM, clean sand, clay soil and sandy soil in the ration of 2:1:1:1, followed by 10 minute treatment with hot water with, FYM, clean sand, clay soil and sandy soil in the ration of 2:1:1:1 Table 2. In low cost trench greenhouse average annual temperature is maximum 21.33 ± 2.19 °C minimum 2.14 ± 3.69 °C, relative humidity maximum 54.23 ± 2.19 % minimum 34.25 ± 3.69 %, and light intensity was 94547.96 ± 23854.11 were recorded, in trench greenhouse the germination percentage (58.00 ± 2.00) and survivability (50.67 ± 1.53) was also recorded highest with hot water treatment for 30 minute in FYM, clean sand, clay soil and sandy soil in the ration of 2:1:1:1, followed by 10 minute treatment with hot water with, FYM, clean sand, clay soil and sandy soil in the ration of 2:1:1:1 Table 3. In open field condition average annual temperature was maximum 12.33 ± 1.91 minimum -0.15 ± 2.13 °C, relative humidity maximum 31.63 ± 2.24 % minimum 23.37 ± 2.01 %, and light intensity was 112092.59 ± 25694.29 Lux, in open field the germination and survivability percentage was observed very low even treated with 30 minutes hot water (23.00 ± 2.00) and 10 minutes hot water treatment (11.21 ± 1.09) Table 4.

Transplanted saplings from poly carbonate to open field were survived 40%, transplanted saplings from polynursery bags to open field were survived 80% figure 8.

Discussion

Based on present study *E. gerardiana* is an important plant species for local dwellers and Amchies who take care of health of the inhabitants of the region, and other part of the world. Many important active compounds are obtained from the species having high demand globally. Owing to its many important medicinal and folk importance leads to over exploitation and habitat degradation, due to which it may extinct from the wild of cold desert of Ladakh, study also confirm that the species has very low density individual/m² in the region, study conducted by Samant and Pant (2006) using IUCN criteria in the Himalayan region also confirmed that it is on brink of extinction on distribution of *E. gerardiana* therefore, it's very important to conserve the species. On the basis of density of the species in the region and ethno-botanical study, optimization of cultivation techniques was made, for standardization of the packages and practices we opt for the simple seeds treatments with hot water with different timing and used high cost and low cost greenhouses to raise the nurseries so that distinguish farmers can afford for the cultivation of the *E. gerardiana*. The study revealed that freshly harvested seeds can be used to raising the nursery which required quite moist and warm temperature, therefore different protective conditions is recommended coupled with hot water treatment is highly recommended. The freshly harvested seeds collected from the wild has 70-80 germination percentage in the protective condition and nurseries are ready to transplant in 3 months were they get the average temperature 35.52 °C and relative humidity was 56.49 percentage. As the density of the species is very low in the wild due to poor germination percentage and survival of the species in the open condition. Non-favourable environmental condition in open condition where annual maximum average temperature is 12 °C and annual average relative humidity was 2.24 % as study revealed that for the maximum germination of the seeds of *E. gerardiana* it required maximum temperature of 35°C and relative humidity of 57 %. The study also revealed that the approach for the cultivation and conservation of *E. gerardiana* is very simple it does not required any rocket science. For maximum survival and in-situ, ex-situ conservation we recommended to transplant the nurseries from protective condition to poly-nursery bags in open condition under maximum care for one year for proper development of roots and then can be transplant in open field for maximum survival. Study on packages and practices and population census on the *E. gerardiana* is the first hand information and this can be used as base for the cultivation and conservation of the species ex-situ, in-situ in the region and other part of India and the world with similar topography.

Declarations

AUTHOR(S) CONTRIBUTION

1. Tsewang Rinchen: have made substantial contributions to conception and design, extensive field survey, collection of data, data analysis, interpretation of data, and drafting of manuscript;
2. Padma Gurmet: have revising manuscript critically for important intellectual content, given final approval of the version to be published.
3. Punchok Dolker: have made extensive field survey, collection of data, data analysis.
4. Tashi Stobgais: have made ethnobotanical studies, folk claims etc.

ETHICAL RESPONSIBLE

It is certified that the work of manuscripts is original contribution of Authors and has not been published anywhere in any form, not been submitted to other journal for simultaneous consideration.

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CONFLICT OF INTEREST

The authors declared that there is have no conflict of interest.

CONSENT TO PARTICIPATE

The study was on Plant species so there is no human or animal participants.

CONSENT TO PUBLISH

The corresponding author warrants that contribution is original and has full power to make this grant. The author signs for and accepts responsibility for releasing this material on behalf of any and all co-authors. This transfer of publication rights covers the non-exclusive right to reproduce and distribute the article, including reprints, translations, photographic reproductions, microform, electronic form (offline, online) or any other reproductions of similar nature.

DATA AVAILABILITY STATEMENTS

All data generated or analysed during this study are included in this article.

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Tables

Table 1. Site characteristics and densities of *Ephedra Gerardiana* and major associate species in Ladakh.

S.No.	Habitat	Altitude (m)	Density (ind/m ²)	Associated species (ind/m ²)
1	Exposed dry	3186	3.5	<i>Artemisia</i> sp (5.7)
2	Bouldery	3241	3.85	<i>Artemisia</i> sp (3.15), <i>Tanacetum</i> sp (3.62)
3	Bouldery	3391	1.85	<i>Acantholimon lycopodioides</i> (1.8)
4	Bouldery	3498	3.2	<i>Tulipa aitchisonii</i> (4.95), <i>Arnebia euchroma</i> (3.65),
5	Bouldery	3531	1.35	<i>Arnebia euchroma</i> (2.5)
6	Bouldery	3519	2	<i>Artemisia</i> sp. (2.8)
7	Exposed dry	3492	1.1	<i>Bergenia stracheyi</i> (3.45), <i>Artemisia</i> sp. (3.8)
8	Exposed moist	3146	0.9	<i>Physochlaina praealta</i> (4.8), <i>Cirsium</i> sp. (5.35)
9	Exposed moist	3165	0.8	<i>Physochlaina praealta</i> (2.75), <i>Cirsium</i> sp. (5.5)
10	Exposed dry	3244	1.25	<i>Arnebia euchroma</i> (3.95)
11	Exposed dry	3228	0.55	<i>Heracleum pinnatum</i> (3.15),
12	Bouldery	4127	0.45	<i>Heracleum pinnatum</i> (3.15), <i>Saussurea jacea</i> (1.1)
13	Exposed dry	4012	1.35	<i>Arnebia euchroma</i> (1.6), <i>Lindelofia stylosa</i> (2.0)
14	Bouldery dry	3764	0.2	<i>Tanacetum gracile</i> (4.21)
15	Exposed dry	4019	0.7	<i>Arnebia euchroma</i> (3.7), <i>Euphorbia</i> sp. (1.7)
16	Exposed dry	4099	1.35	<i>Arnebia euchroma</i> (2.35), <i>Lindelofia stylosa</i> (1.3)
17	Exposed dry	4054	1.05	<i>Arnebia euchroma</i> (1.55), <i>Potentilla</i> sp (1.7)

Table 2. Polycarbonate protective condition

treatment	Germination %			Survival %			Plant height			Number of Leaf			Hot water 30 min	Hot water 10 min
	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control		
1:1:1	82.67±3.79	78.33±2.08	52.00±2.65	89.00±4.36	75.67±4.04	73.33±3.51	67.00±1.00	64.00±2.00	62.00±1.00	31.67±1.53	31.33±2.08	30.33±4.73	18.33±1.53	18.33±1.53
2:1:1	63.67±2.08	61.33±0.58	47.67±3.21	75.33±2.08	55.00±5.29	66.67±2.08	49.00±1.00	46.67±3.21	46.67±3.51	14.33±1.53	15.00±1.73	14.33±1.15	16.33±1.15	16.33±1.15
1:2:1	58.67±1.53	57.67±1.53	36.00±3.61	63.00±2.00	30.67±0.58	47.33±1.53	34.00±2.65	31.33±2.31	32.00±1.00	12.00±2.00	10.67±1.53	12.00±2.65	11.67±1.08	11.67±1.08
1:1:2	68.33±1.53	65.33±0.58	51.67±2.08	63.67±2.08	41.33±2.31	65.00±3.61	45.00±1.00	41.67±0.58	44.33±1.53	23.00±1.73	20.33±0.58	22.00±2.00	15.67±1.53	14.67±1.53
YM	21.33±0.58	20.00±1.00	16.00±2.65	9.67±0.58	8.67±0.58	10.67±1.15	21.67±1.53	20.00±1.00	21.00±1.00	8.33±1.53	8.00±1.00	7.67±1.53	9.33±0.58	9.33±0.58
lean sand	34.33±0.58	31.00±1.00	28.00±1.00	11.33±0.58	10.00±1.00	10.33±2.31	25.00±0.00	23.33±1.53	23.33±1.53	6.33±0.58	6.33±0.58	6.33±1.53	8.33±2.52	8.33±2.52
dry Soil	27.00±2.00	22.33±1.53	19.33±0.58	7.00±31.00	6.33±0.58	7.67±2.08	21.00±1.00	19.00±1.00	19.33±0.58	5.00±1.00	5.00±1.00	4.33±1.53	9.33±2.08	8.33±2.08
andy soil	38.00±3.61	35.00±5.57	32.00±2.65	54.67±4.16	40.67±0.58	62.00±3.00	33.67±2.52	31.33±0.58	31.33±1.53	16.67±2.08	15.33±2.52	15.67±2.52	15.00±1.73	14.33±1.53

Table 3. Trench protective condition

treatment	Germination %			Survival %			Plant height			Number of Leaf			Hot water 30 min	Hot water 10 min
	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control		
1:1:1	58.00±2.00	57.33±2.08	50.33±0.58	50.67±1.53	49.33±3.79	71.33±3.21	63.00±2.00	62.33±1.53	57.00±0.87	30.67±1.53	30.00±5.29	39.34±3.57	17.67±1.53	17.67±1.53
2:1:1	54.33±2.25	50.67±1.53	47.67±3.21	46.67±2.08	43.67±2.08	61.67±1.28	47.33±2.08	46.67±2.52	42.56±3.21	13.67±1.53	14.00±2.00	13.29±1.06	15.67±0.58	15.67±0.58
1:2:1	41.00±1.00	39.33±1.53	36.00±3.61	34.00±2.00	32.00±1.00	43.33±1.43	31.67±1.15	32.00±1.00	28.10±0.89	11.33±1.53	11.33±2.08	11.10±1.98	10.67±2.08	10.67±2.08
1:1:2	58.33±0.58	55.00±1.00	51.67±2.08	46.00±2.65	44.00±2.65	63.20±3.01	44.67±1.53	44.33±1.53	39.28±1.35	22.33±1.53	22.00±1.00	20.97±1.87	14.67±1.53	14.67±1.53
YM	21.00±1.00	18.33±1.53	16.00±2.65	10.67±1.53	10.00±1.00	9.87±1.51	21.00±1.00	21.67±0.58	19.06±0.88	7.67±1.53	7.67±2.31	6.96±1.21	8.33±1.53	8.33±1.53
lean sand	33.00±1.00	30.00±1.00	28.00±1.00	12.00±1.00	10.33±1.53	9.13±2.21	24.67±1.53	23.33±1.53	21.29±1.21	5.67±0.58	6.00±1.00	5.68±1.35	7.67±2.53	7.67±2.53
dry Soil	24.67±1.15	21.33±0.58	19.33±0.58	8.00±1.73	7.33±1.00	6.54±1.88	20.00±1.00	19.67±1.53	18.24±0.49	4.33±1.53	4.33±1.53	3.96±0.99	8.67±2.52	8.67±2.52
andy soil	38.00±3.00	35.33±3.21	32.00±2.65	45.67±3.06	43.00±2.00	55.00±2.00	32.00±1.00	31.00±1.00	29.26±0.98	16.00±1.73	15.67±2.08	13.86±1.87	14.33±1.53	14.33±1.53

Table 4. Open condition

treatment	Germination %			Survival %			Plant height			Number of Leaf			Hot water 30 min	Hot water 10 min
	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control	Hot water 30 min	Hot water 10 min	Control		
1:1:1	23.00±2.00	11.21±1.09	10.32±1.08	56.68±2.14	42.54±2.98	41.54±2.52	34.33±0.58	33.33±0.87	35.33±1.09	31.00±1.99	29.87±1.98	29.56±1.76	17.33±1.05	16.33±1.05
2:1:1	19.00±1.00	5.07±0.01	4.76±0.18	18.63±1.01	15.98±0.03	14.76±0.43	28.67±0.21	28.33±1.53	29.67±0.99	14.67±0.88	13.67±0.65	12.98±0.35	14.67±0.58	13.67±0.58
1:2:1	12.67±2.52	4.66±0.65	3.54±1.15	22.67±1.02	15.76±0.56	14.98±1.00	32.00±1.00	30.67±1.97	32.33±1.03	12.00±1.02	11.78±1.01	11.21±1.03	10.33±1.15	9.33±1.15
1:1:2	19.33±1.53	7.33±0.89	5.97±1.00	29.67±0.32	16.76±0.57	16.86±0.89	33.33±1.03	31.67±1.77	33.33±1.76	22.00±1.73	21.99±1.73	22.12±0.89	14.67±1.53	12.67±1.53
YM	5.33±0.58	1.03±0.06	0.23±0.56	6.78±0.12	5.87±0.01	5.13±0.98	24.33±0.12	22.67±1.98	24.67±1.65	8.67±0.58	7.89±0.58	7.31±0.78	8.67±0.24	7.67±0.24
lean sand	2.67±0.58	2.67±0.68	1.02±0.87	8.98±0.23	7.87±0.21	6.89±0.21	22.00±1.47	21.67±0.99	22.67±1.87	6.33±1.53	5.63±0.78	6.21±0.06	6.33±0.58	6.33±0.58
dry Soil	1.67±0.58	1.67±0.52	0.67±0.69	7.33±0.68	4.87±0.03	3.98±0.23	21.33±2.80	17.67±0.78	19.33±0.98	5.33±1.53	4.98±0.60	3.99±0.32	8.67±0.98	7.67±0.98
andy soil	7.00±0.23	9.32±1.01	6.35±0.58	29.76±1.87	27.98±1.89	22.87±1.42	31.00±1.99	25.33±1.89	31.33±1.21	15.67±3.51	14.56±1.87	14.21±1.02	15.33±1.02	13.67±1.02

Figures

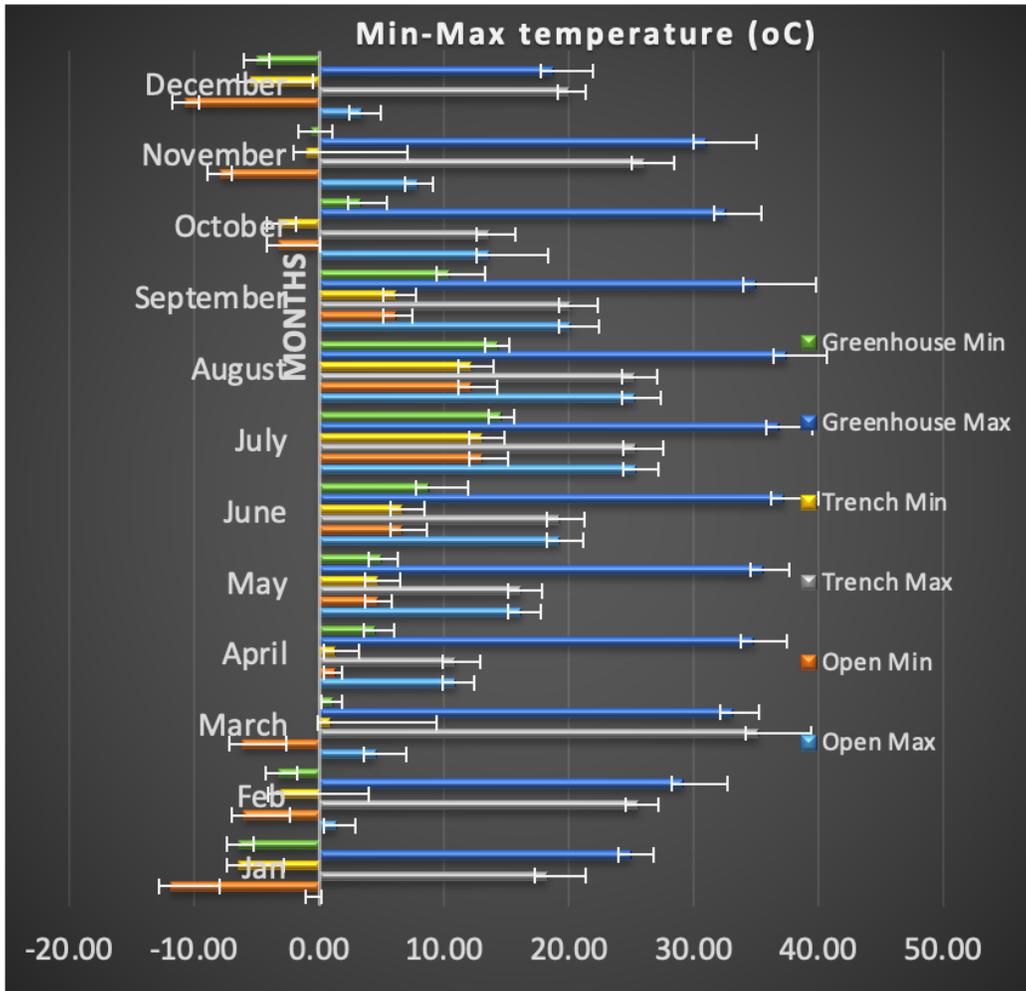


Figure 1

Average \pm monthly temperature (oC) of different conditions

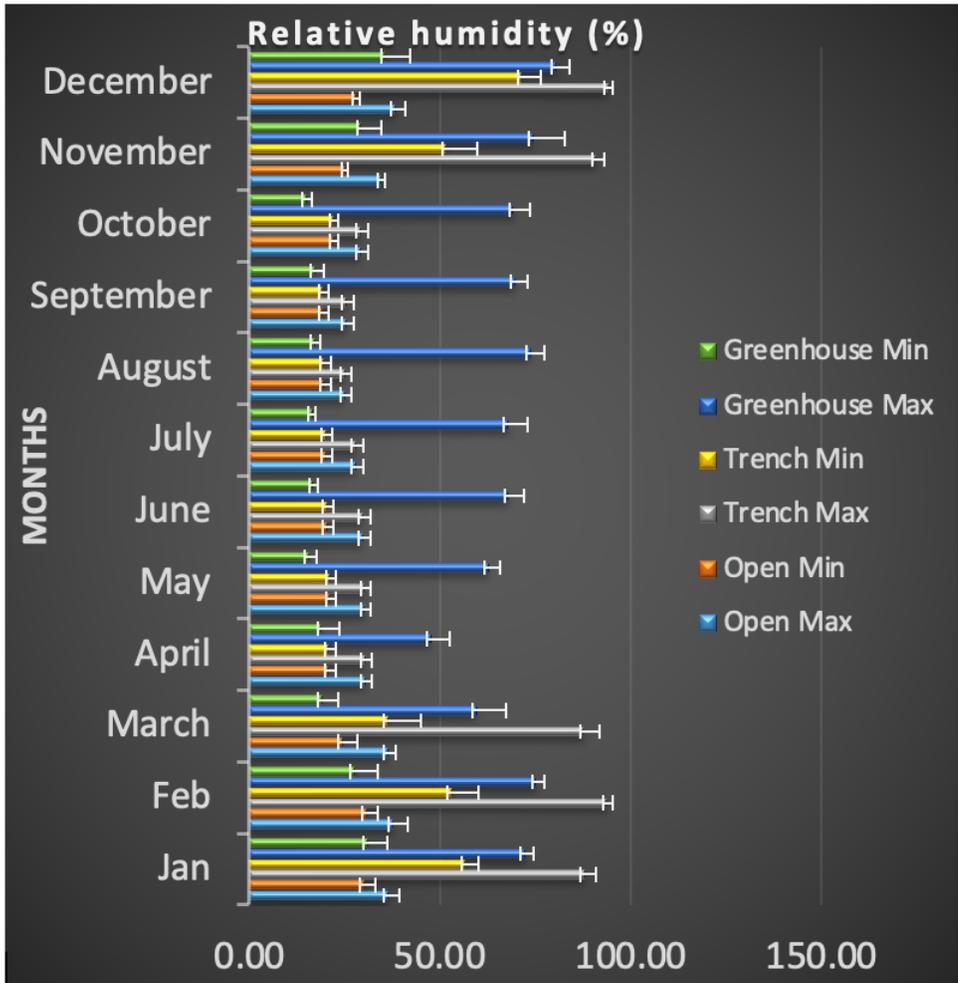


Figure 2

Average ± monthly RH (%) of different conditions

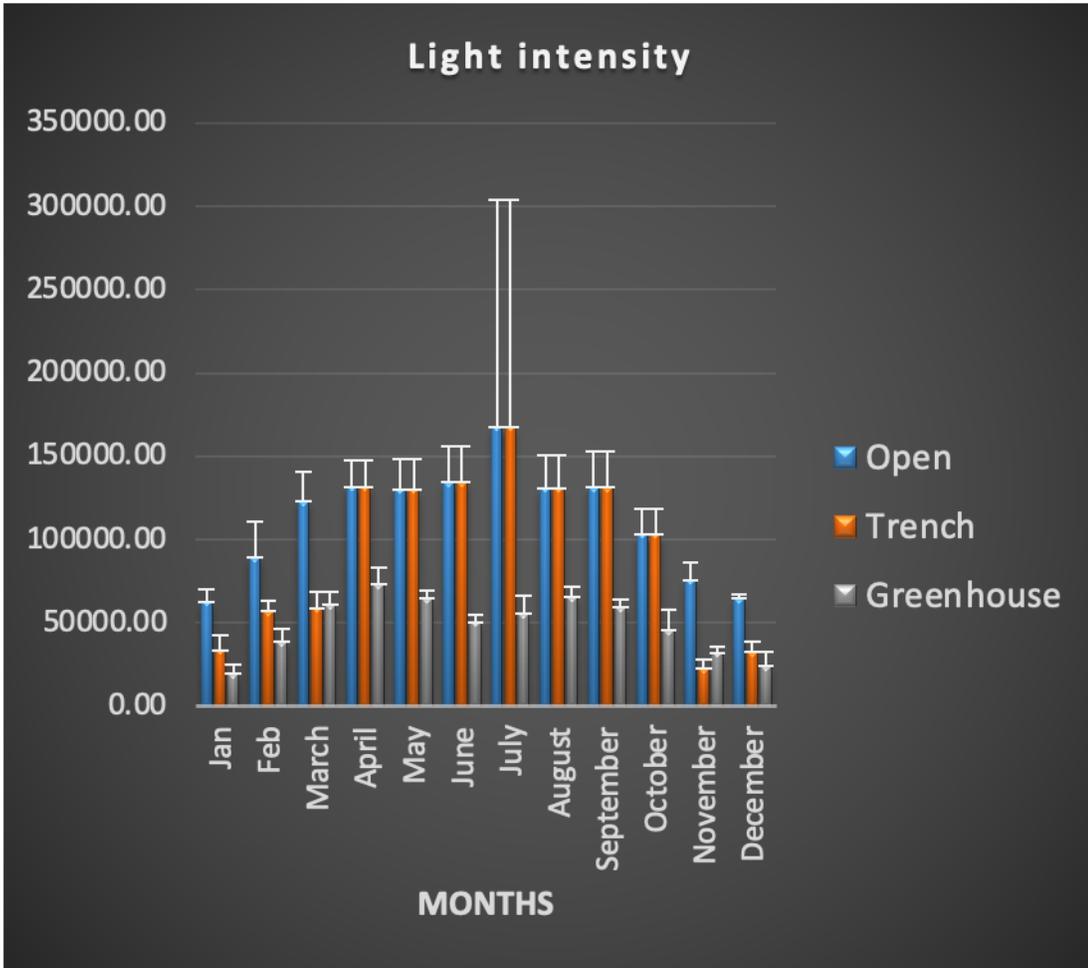


Figure 3

Average ± monthly light intensity of different conditions



Figure 4

Ephedra gerardiana



Figure 5

Transplant from greenhouse to open field



Figure 6

Transplant of nurseries in poly-nursery bags.



Figure 7

Transplant from polynursery bag to open field

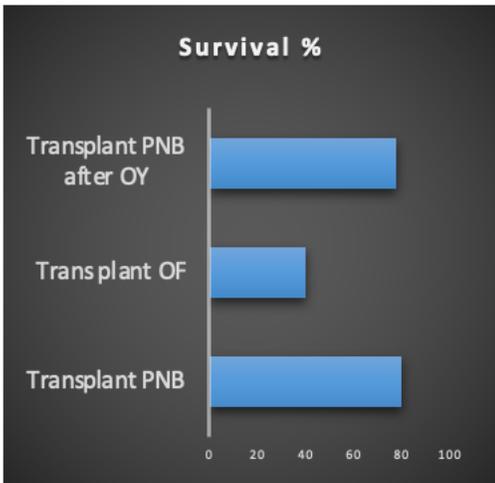


Figure 8

Survival percentage of *E. gerardiana* in open field. Abbreviations: PNB=Polynursery bags, OY=One year, OF=Open field