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Gregarious Colonization of *Tribulus terrestris* L. (Puncture Vine) : Ecological Implications

Amit K. Tripathi, Jyoti K. Sharma, Ganesh D. Bhatt, Mohd Ahmad

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Abstract A study was carried out to investigate gregarious colonization and lateral spread (area covered) of *Tribulus terrestris* (Puncture Vine) in 2.71 ha barren area through quadrat sampling. The lateral spread of each plant in 271 quadrat (10 m × 10 m size) was measured. The soil was fertile alluvial soil containing fine sand (69.6%), silt (13.6%) and clay (15.2%), characteristic of soils in Wheat-Rice agriculture system in southwestern plain of Upper Gangetic Plain. The frequency and density of plants recorded were 75.28% and 3.76 individuals / 100 m^2, respectively whereas abundance was five. The total area covered by the lateral spread of the plant in the plot was 523.80 m^2 with an average spread area of an individual Puncture Vine to 0.51 m^2 and maximum of 3.30 m^2. The phytosociological study revealed the aggressive growth of *T. terrestris* among 46 plant species recorded ; a few species such as *Dactyloctenium aegyptium* and *Trianthem aportulacastrum* appeared to have allelopathic effects on *T. terrestris*. The growth of Puncture Vine was affected in water logged soil suggesting that it prefers drier soils. The gregarious growth of *T. terrestris* recorded for the first time possibly be attributed to its aggressiveness, less competition from other species as the area was almost barren with a very few herbs, plenty of sunshine (as there was no tree growth) throughout, higher temperature coupled with favorable soil conditions. This is the first time lateral spread of a prostrate plant has been studied and being reported. The study has important ecological implications from the point of view of introduction of Puncture Vine in wastelands for large scale production of raw material of this important medicinal plant having great demand by Ayurvedic industries in India.

Keywords Lateral spread, Quadrat sampling, *Tribulus terrestris*, Aggressive growth, Ecological implications.

Introduction

Tribulus terrestris L. is a tap rooted, annual (sometimes perennial in warm climates), spreading (prostrate) herb belonging to the family Zygophyllaceae and distributed throughout tropical India. It is commonly known as Puncture Vine (*Gokhru* in Hindi, *Gokshura* in Sanskrit) as it bears the caltrop like seeds and when matured they are capable of puncturing feet, animal hooves and even vehicle tyres. *T. terrestris*, a native of tropical America, is widespread throughout the world from latitudes 35ºS to 47ºN (Holm et al. 1977). It is a common weed of Upper Gangetic Plains of India and grows throughout the country along the

Amit K. Tripathi*, Jyoti K. Sharma, Mohd Ahmad
Center for Environmental Sciences & Engineering, School of Natural Sciences, Shiv Nadar University, Greater Noida, Gautam Buddha Nagar 201314, UP, India

Ganesh D. Bhatt
School of Agriculture, Galgotias University, Greater Noida, Gautam Buddha Nagar 201310, UP, India
e-mail: amitnehu@gmail.com
*Corresponding author

roadsides, wastelands, boundaries of agricultural fields and sandy localities.

Taxonomic description : Annual or perennial prostrate herb, clothed with silky hairs. Stem much-branched from the base ; branches up to 3 m long, silky-villous. Leaves abruptly paripinnate ; leaflets small, 5–7 pairs, oblong, entire, mucronate at apex, oblique at base, hairy, Stipules subulate. Flowers yellow, solitary, axillary or pseudo axillary. Calyx lobes-5, lanceolate, pubescent, slightly ciliate at margin. Corolla lobes-5, petal free, oblanceolate, Stamens-10, Stigma 5-rayed. Fruits schizocarpic, spinous, villous, usually with 5 woody cocci ; each cocci with 2 or 4 spines.

Puncture Vine seeds germinate in mid to late spring season (April to May) and flowering and fruiting starts within three weeks after the emergence. The plants continue to spread laterally and develop fruits until the growth stopped at the advent of frosty winters. As the fruits are spiny, they are carried over to the long distances by the vehicle tyres and animal hooves. Pathak (1967, 1970, 1971), who has extensively worked on the ecology of Puncture Vine, observed that plants prefer sunny condition and usually do not grow in shade ; it produces maximum seeds in crop fields where soil is much porous and rich in organic matter and the successful colonization of an area can only be expected after a good seed production.

Being medicinally important the phytochemistry of *T. terrestris* has been extensively studied and the occurrence of saponins, flavonoids, glycosides, alkaloids, lignanamides and cinammic acid, amides and tannins has been reported ; the fruit and root contain pharmacologically important metabolites such as phytosteroids, flavonoids, alkaloids and glycosides (Jameel et al. 2012, Chhatre et al. 2014, Hashim et al. 2014).

Various parts of *T. terrestris* are sweet, cooling, diuretic, aphrodisiac, palliative, emollient, appetizer, digestive, anthelmintic, expectorant, antihypertensive, anodyne, anti-inflammatory, alterant, laxative, cardiotonic, styptic, lithontriptic, tonic, astringent, abortifacient and depurative (Warrier et al. 2010, Jameel et al. 2012, Hashim et al. 2014, Shaheen et al. 2014). *T. terrestris* is one of the 46 medicinal plant species in high trade sourced mainly from wastelands for Ayurvedic Industries in India (Ved and Goraya 2007). It has been widely used in the Ayurvedic as well as traditional system of medicine in India and other parts of world for the treatment of various ailments, especially sexual dysfunction, infertility, as a testosterone booster and for the cure of various urinary disorders for centuries. In India, *T. terrestris* is also used extensively in folk medicine for the treatment of cancer, male infertility, painful urination, calculous affections and Bright's disease, digestive disorders, immune disorders, stress, eczema, psoriasis, angina, high blood pressure, high cholesterol, kidney stones and also improves blood circulation and as an aphrodisiac in traditional medicines (Warrier et al. 2010, Jameel et al. 2012, Kor et al. 2013, Yadav 2013, Hashim et al. 2014). The different parts of the plant has strong antibacterial and antifungal activities (Al-Bayati and Al-Mola 2008). It is one of ingredients of famous Ayurvedic health tonic Dasamoolarishta. It is a vital constituent of *Gokshuradi Guggulu*, a potent Ayurvedic medicine used to support proper functioning of the genitourinary tract (Chhatre et al. 2014).

During December 2014—February 2015, the Botanic Garden of Shiv Nadar University was being developed and soil from nearby agriculture fields was being filled in 2.71 ha for levelling the entire area ; the remaining area of the garden (1.15 ha) was part of wetland and not included in the study as there was no population of *T. terrestris* recorded. After the onset of showers during late June to early July within a month or so the whole area was seen getting colonized with plants of *T. terrestris.* The gregarious colonization of *T. terrestris* caught the attention for it being so striking due to pure growth of the species. Since there was no study available on such a gregarious colonization of almost barren area with Puncture Vine, it was decided to conduct a quantitative study. The paper presents details of colonization of almost a barren area of Botanic Garden of Shiv Nadar University by Puncture Vine through quadrat sampling and discusses its ecological implications.

Materials and Methods

Study site

The Shiv Nadar University (SNU), Gautam Buddha Nagar, Uttar Pradesh, India has an area of 115.74 ha (286 acre). The study was conducted in SNU's Botanic Garden (Latitude 28º31´19.28´´ N, Longitude 77º34´35.10´´ E ; Alt. : 195 m) which was started to be established in low lying area of the campus. The Botanic Garden, located adjacent to wetlands, Sisona Jheel, near the eastern boundary of the campus, has an area of approx. 3.86 ha (dryland-2.71 ha, wetland –1.15 ha). Initially, the low lying area where the garden was to be established, had luxuriant growth of *Saccharum spontaneum* and *S. bengalense* which was uprooted and cleared of all weeds before filling with fresh agriculture soil brought from nearby agriculture fields ; the soil was ploughed thoroughly and leveled during the months of December 2014—February 2015. Initially, some of the winter weeds belonging to Brassicaceae (*Capsella bursa-pastoris*, *Cardamine hirsuta*, *Lepidium didymium*, *Sisymbrium irio*), Caryophyllaceae *(Arenaria serpyllifolia*, *Silene conoidea*, *Spergula arvensis*, *Stellaria media*), Leguminosae (*Vicia sativa*), Plantaginaceae (*Veronica agrestis*), Polygonaceae (*Polygonum plebeium*, *Rumex dentatus*) and Primulaceae (*Anagalli sarvensis*) families started to appear scattered on the barren soil during winter (January-March 2015). Some of the species continued to grow even during summer (April–June 2015). Hence, the area had scattered vegetation of annual weeds until the onset of pre-monsoon showers during late June to early July.

Climate

The climate of the Gautam Buddha Nagar district is sub-humid and characterized by hot summer and bracing cold season. The district experiences the hottest weather in the month of June with average mean temperature of 32.85ºC followed by May with 31.9ºC. The coldest month is January with average mean temperature of 14.2ºC followed by December with 15.4ºC (Joshi 2008-09).

The annual normal rainfall (1901–1970) of the district is 700.6 mm received during the monsoon period, June to September. August is the wettest month having the normal rainfall of 205.8 mm followed by July when normal rainfall received about 194.4 mm (Joshi 2008-09).

Soil

Soil samples were collected at a depth of 10–20 cm from five locations in the Botanic Garden and pooled together for studying physical and chemical properties of the soil. The soil analysis was carried out at ICAR-Institute of Soil and Water Conservation, Dehradun, Uttarakhand State.

Field sampling and data analysis.

The sampling of *T. terrestris* was done in SNU's Botanic Garden during July-September 2015. Individual plant of Puncture Vine was sampled in 271 quadrats of 10 m × 10 m size covering a total area of 2.71 ha area. For assessing the area of spread of individual plant, 1 m × 1 m size quadrat was used within 10 m × 10 m quadrat. Quantitative analysis was done following Misra (1968). The data were analyzed for number of individuals in each quadrat, frequency, density, abundance and total area covered by all the individuals of Puncture Vine in each quadrat. The phytosociology of Puncture Vine plant was also recorded to ascertain the competitive ability / association of Puncture Vine with other plant species. Though the occurrence of *T. terrestris* was continued to be observed in subsequent years during 2016-18 but no systematic observations were recorded due to the fact that the garden activities of planting and weed cutting / removal had started in the garden and consequently there was lot of ecological disturbances.

Results and Discussion

The Botanic Garden soil brought from nearby agricultural fields was fertile alluvial soil containing fine sand (69.6%), silt (13.6%) and clay (15.2%), characteristic of soils represented in Wheat–Rice agriculture system in southwestern plain of Upper Gangetic Plain (Sharma et al. 2012). The soil was slightly alkaline (8.16) with reasonably good maximum water holding

Table 1. Physical and chemical properties of soil. OC–Organic Carbon, EC–Electrical Conductivity, MWHC–Maximum Water Holding Capacity, BD–Bulk Density, PD–Particle Density, *Sharma et al. (2012), (Southwestern plain of Upper Gangetic Plain), #Apal Agricultural Laboratory–Soil test interpretation guide.

Physical parameters	Value	Desirable range	Chemical parameters	Value	Desirable range
Fine Sand (%)	69.6	46.4–82.4*	pH (1 : 2.5)	8.16	5.9–9.5*
Coarse Sand (%)	1.6	–	OC (%)	0.400	0.05–2.55*
Silt (%)	13.6	4.0–32.8*	EC (dSm^{-1})	0.164	0.08–0.86*
Clay (%)	15.2	10.8–31.0*	N (%)	0.032	0.15–0.25#
BD (g/cm^3)	1.36	–	P (ppm)	3.8	4.5–96.3*
PD (%)	40.93	–	Ca^+	0.102	–
MWHC (%)	39.31	–	Mg^+	0.116	–
			Cu (ppm)	1.837	–
			Zn (ppm)	0.620	–
			Mn (ppm)	12.066	–
			Fe (ppm)	6.770	–

capacity (MWHC) of 39.31% (Table 1). Nutrient-wise the soil contained OC (0.400%) which is within the desirable range of soils of Upper Gangetic Plain.

The soil was characterized by low P (3.8 ppm) and N (0.032%). The low P and N contents could be due to fallow condition of the agriculture field from where the soil was collected and changes in biochemical and physical composition of soil organic matter and a gradual decline in the supply of soil nutrients, causing macro and micronutrient imbalances due to inappropriate fertilizer applications over a period of time (Ladha et al. 2000). Pathak (1970) has also earlier recorded that *T. terrestris* grows on soils low in nitrogen (Pathak 1970). The desirable range of N (%) is 0.15–0.25 (Apal Agricultural Laboratory—Soil test interpretation guide). Further, it has been reported that the soils of southwestern plain of Upper Gangetic Plain are deficient in N and P content in due to intensive cultivation of agricultural crops (Sharma et al. 2012). The soil characteristics described by Pathak (1970) for Ramnagar (agriculture field) for the establishment of Puncture Vine are at variance to our study probably because the differences in the location of study sites. While the present study site falls in southwestern plain of Upper Gangetic Plains having fertile alluvial poorly drained soil, Pathak's (1970) study sites is under eastern plain of middle Gangetic Plains having fertile alluvial well drained soil. In our study the amount of coarse sand was very low (1.6%) in comparison to Pathak (1970) (22.25 to 38.56), whereas clay (15.2%) is higher than as reported by Pathak (1970) (2.45 to 4.85%). Nutritionally also the soil described by Pathak (1970) is rich in N (0.1575%), OM (3.94%) and Ca (36.44).

Soil characteristics are very important for seed germination and establishment and growth of plants. In India, *T. terrestris* is found primarily on loose and compact sandy loam soils and reportedly grows on sand dunes in the desert regions (Pathak 1970). In Australia, it is found on sandy and silty and on saline soils (Squires 1979). It also thrives on loose, blown soil by field margins (Holm et al. 1977). Plants are typically more robust on sites without compacted soils (Pathak 1970), yet can grow on compacted soils, such as those found along side unsurfaced roads and in playgrounds (Holm et al. 1977). It also can grow in heavier soils, especially when fertile and moist (Holm et al. 1977).

As the garden was exposed to sun light the top soil became dry and hard and winter weeds started to wither during summer. The soil of Botanic Garden having such harsh conditions was colonized gregariously by Puncture Vine plants after the first rains indicating that it has the capacity to establish in almost a barren area and colonize aggressively. Since there were no Puncture Vine in the original vegetation of the site or in surrounding areas of the SNU campus probably the Puncture Vine seeds / fruits were transported in the soil from the agriculture fields. During field observations in Botswana also, *T. terrestris* was observed to germinate and emerge following

Table 2. Phytosociological attributes.

Sl. No.	Attributes	Value
1	Total area covered	2.71 ha (6.7 acre)
2	Total number of quadrats laid	271
3	Total number of quadrat in which *T. terrestris* found	204
4	Frequency	75.28%
5	Density (Total no. of individuals)	1019
6	Density / m^2	0.04
7	Density / 100 m^2	3.76
8	Abundance	5
9	Quadrat having maximum number of individuals	27
10	Quadrat having largest area of *T. terrestris* (m^2)	11.43
11	Total area covered by *T. terrestris* (m^2)	523.80 m^2
12	Average spread area of an individual	0.51 m^2
13	Maximum spread area of an individual	3.30 m^2

a rain shower having more than 0.04 in (10 mm) of precipitation (Ernst and Tolsma 1988). Maximum germination occurred after a series of heavy rains, facilitating a 35% germination rate, with continued germination of seeds lasting for another 4 months (Ernst and Tolsma 1988). Our observations also conform to earlier findings that generally, *T. terrestris* has a considerable seed dormancy lasting over fall and winter months (Washington State Noxious Weed Control Board) with some seeds staying dormant for longer periods of time. *T. terrestris* germinates after the start of the monsoon rains, on any type of barren soil, in Southern Arizona (Parker 1972). In Washington and Australia, it germinates in the late spring to early summer, when necessary soil moisture conditions are met (Squires 1979, Washington State Noxious Weed Control Board).

The total area covered by the Puncture Vine in the sampled plot was 523.80 m^2 of the area with an average spread area of an individual plant to 0.51 m^2 and maximum spread of 3.30 m^2. The maximum number of individual plants of Puncture Vine in a single quadrat was as high as 27 individuals. The highest area of 11.43 m^2 (Table 2) was covered by 19 Puncture Vine plants in one of the quadrats. There were a total of three quadrats covered by more than 10 m^2 area of Puncture Vine. In addition a total of 32 quadrats were covered by 5-<10 m^2 area of the plant. There were a total of 14 quadrats which had only one individual but covered 1 or more than 1 m^2 area. In addition, some interesting trends emerged from the study with regard to colonization of Puncture Vine plants. One fourth of the garden on northern side had little population of Puncture Vine and the plant area / size of the plants was relatively smaller. A total of 67 quadrats (24.72%) did not record any plants. Southern side quadrats had more number of plants and had relatively larger spread. In northern side 44% (59 out of 134 quadrats) of the quadrats were devoid of Puncture Vine plants whereas on southern side there were only 6% of the quadrats (8 out of 137 quadrats) which did not have any Puncture Vine plants.

Due to its ability to extract soil moisture from great depth in the soil, *T. terrestris* competes well with other species (Holm et al. 1977). The phytosociological study revealed that 45 plant species from 19 families and 42 genera were associated with *T. terrestris* (Table 3). Amaranthaceae, Leguminosae and Malvaceae were the most speciose family with 5 species each. Out of 45 plant species found associated with *T. terrestris* many species were also recorded by Pathak (1970) viz ; *Boerhavia diffusa*, *Cynodon dactylon, Cyperus rotundus, Cyanotis axillaris, Cleome viscosa, Dichanthium annulatum, Digera arvensis / muricata, Euphorbia alba / prostrata, Gomphren acelosioides, Tephrosia purpurea* (Table 3). Though Puncture Vine grew gregariously, it was also observed that wherever dense population of *Dactyloctenium aegyptium* (Egyptian crowfoot grass) was present *Gokhru* was either absent or plants remained restricted in their lateral spread indicating some allelopathic effect. In an earlier study aqueous extracts of *D. aegyptium* have been found to be inhibitory to rice emergence and seedling growth suggesting a possible

Table 3. List of plant species associated with *Tribulus terrestris*. (H–Herb, US–Undershrub, SH–Shrub, CR–Creeper).

Sl. No.	Name of the plant species	Family	Vernacular / Hindi name	Habit
1	*Abutilon indicum* (L.) Sweet	Malvaceae	Kanghi, Kakahi	SH
2	*Achyranthes aspera* L.	Amaranthaceae	Chirchita, Latjira	H
3	*Ageratum houstonianum* Mill.	Compositae	Raktarodhi	H
4	*Alysicarpus vaginalis* (L.) DC.	Leguminosae	...	H
5	*Amaranthus viridis* L.	Amaranthaceae	Jangli Chaulai	H
6	*Boerhavia diffusa* L.	Nyctaginaceae	Punarnava	H
7	*Brachiaria reptans* (L.) C. A. Gardner & C. E. Hubb.	Poaceae	...	H
8	*Calotropis procera* (Aiton) Dryland.	Apocynaceae	Aak, Madar	US
9	*Cannabis sativa* L.	Cannabaceae	Bhang	H
10	*Chenopodium album* L.	Amaranthaceae	Bathua	H
11	*Cleome viscosa* L.	Cleomaceae	Pili Hurhur	H
12	*Commelina forsskalii* Vahl	Commelinaceae	Kankawwa	H
13	*Crotalaria medicaginea* Lam.	Leguminosae	Jhojhru	H
14	*Croton bonplandianus* Baill.	Euphorbiaceae	Ban Tulsi	H
15	*Cyanotis axillaris* (L.) D. Don ex Sweet	Commelinaceae	Kana	H
16	*Cynodon dactylon* (L.) Pers.	Poaceae	Doob	H
17	*Cyperus rotundus* L.	Cyperaceae	Motha	H
18	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	Makra Ghas	H
19	*Datura innoxia* Mill.	Solanaceae	Safed Dhatura	H
20	*Dichanthium annulatum* (Forssk.) Stapf	Poaceae	Delhi/Sheda Grass	H
21	*Digera muricata* (L.) Mart.	Amaranthaceae	Lehsua	H
22	*Eclipta prostrata* (L.) L.	Compositae	Bhringraj	H
23	*Erigeron bonariensis* L.	Compositae	...	H
24	*Euphorbia hirta* L.	Euphorbiaceae	Bara Dudhi	H
25	*Euphorbia heterophylla* L.	Euphorbiaceae	...	H
26	*Fimbristylis dichotoma* (L.) Vahl	Cyperaceae	...	H
27	*Gomphrena celosioides* Mart.	Amaranthaceae	...	H
28	*Heliotropium ellipticum* Ledeb.	Boraginaceae	Hathisunda	H
29	*Ipomoea pes-tigridis* L.	Convolvulaceae	Panchpatia	CR
30	*Malvastrum coromandelianum* (L.) Garcke	Malvaceae	Kharenti	H
31	*Melochia corchorifolia* L.	Malvaceae	Chitrabeez	H
32	*Parthenium hysterophorus* L.	Compositae	Gajar Ghas	H
33	*Phyla nodiflora* (L.) Greene	Verbenaceae	Jal Buti	H
34	*Phyllanthus amarus* Schumach. & Thonn.	Phyllanthaceae	Bhuiaonla, Hazarmani	H
35	*Phyllanthus maderaspatensis* L.	Phyllanthaceae	Hazarmani	H
36	*Physalis angulata* L.	Solanaceae	...	H
37	*Polygonum plebeium* R. Br.	Polygonaceae	Machechi	H
38	*Portulaca oleraceae* L.	Portulacaceae	Kulfa, Lunia	H
39	*Rhynchosia capitata* (Roth) DC.	Leguminosae	...	CR
40	*Senna occidentalis* (L.) Link	Leguminosae	Kasundi, Kasonda	US
41	*Sida acuta* Burm.. f.	Malvaceae	Baraira	H
42	*Sida cordifolia* L.	Malvaceae	Kharenti	H
43	*Solanum americanum* Mill.	Solanaceae	Makoi	H
44	*Tephrosia purpurea* (L.) Pers.	Leguminosae	Sharphonka	H
45	*Trianthema portulacastrum* L.	Aizoaceae	Vishakhapara	H

allelopathic interference (Hussain et al. 2013). Also, it was found that profuse growth of *Trianthema portulacastrum* (*Vishakhapara* in Hindi) caused reduced growth of Puncture Vine. Earlier, *T. portulacastrum* has been recorded to have significant inhibitory effect on germination and seedling growth of *Sesamum indicum* (Sutradhar et al. 2017).

However, our results are in contrast to earlier observations of Pathak (1970) that Puncture Vine is not a gregarious species and does not occur in continuous patches. The gregarious growth of Puncture

Vine plants throughout in the present study may be attributed to ample amounts of fruits / seeds already present in the soil and its physical and chemical characteristics and prevailing microclimatic conditions such as plenty of sunshine. Further, its aggressive growth behavior and less competition with other species could also be one of the reasons of such type of gregarious growth of plants.

Given the conducive edaphic and climatic conditions of the area Puncture Vine seeds present in the soil grew rapidly as evident from high frequency of Puncture Vine plants recorded (75.28%) in the garden (Table 2). Of the total of 271 quadrats Puncture Vine was present in 204 quadrats. A total of 1019 individuals (3.76 individuals/100 m^2) of Puncture Vine was recorded in 2.71 ha area of garden. Of the sampled area of 2.71 ha a total of 523.80 m^2 area was covered by Puncture Vine plants clearly showing the aggressive growth of Puncture Vine. Probably poor N and P content and other characteristics of the soil also favored good colonization by Puncture Vine plants. Also, the potentiality of growth of a plant in a particular area is attributed to the suitability of the whole environment in time and space to fit its genetic requirements (Billings 1952). *T. terrestris* showed very aggressive capacity to establish, grow and multiply as it was the first dominated species appeared after land filling of the garden with agricultural soil. The lateral spread of branches of the plant were recorded up to 3 m in length which is higher than reported earlier (Pathak 1967), ultimately showed the favorable environmental condition for gregarious growth of Puncture Vine.

In comparison to northern side, the southern side of the garden had more number of individuals of plants and covered larger areas by *T. terrestris.* This type of heterogeneous distribution and density of plants could be due to difference in slope and moisture regime of northern and southern sides. Some of the area on the northern side also had water logging which could have resulted in no growth of Puncture Vine plants. The growth of Puncture Vine was found to be affected in waterlogged soil of the garden suggesting that it prefers drier soils. Nikolova and Vassilev (2011) have also reported poor growth of *T. terrestris* on waterlogged soils. Our results confirm earlier observation of Pathak (1971) who stated very low moisture requirement suitable for the growth of *T. terrestris*.

Number of Puncture Vine plants in a quadrat did not correlate with the area covered as in some of the quadrats there were higher number of plants but they covered less area probably due to competition among large number of individuals. At the same time there were instances where there were less number of plants in quadrats but they had covered larger area probably due to less competition among the individuals and vigorus lateral spread. A few quadrats recorded 1–3 number of plants but they covered a large area due to extensive lateral spread.

As observed in the study site during the subsequent years the population and growth of Puncture Vine gradually reduced to a great extent probably due to less seed production, species competition and increased moisture regime of the soil due to irrigation in the garden and feeding of fruits / seeds by ants (*Camponotus* sp.) The complete removal of population of Puncture Vine by the attack of an insect and inhibition in seed germination due to low temperatures, low light intensities and wet soil have been reported earlier (Pathak 1967, 1970). Further, the plants growing under intense competition are known to produce less number of seeds consequently decline in the population (Pathak 1971).

Conclusion

Findings of this study have clearly indicated the capacity of *T. terrestris* to colonize almost a barren area after the first monsoon showers and grow vigorusly attaining very large surface area by an individual plant. The gregarious growth of plant may be attributed to its aggressiveness, less competition with other species, plenty of sunshine throughout the garden (as it was barren land initially), higher temperature coupled with favorable soil conditions.

This is the first time lateral spread of a prostrate plant, *T. terrestris* has been studied which can be applied to other prostrate species. Having tremendous medicinal properties and uses, it can be introduced in barren areas or wastelands as a pure crop and livelihoods of farmers, rural/marginal people can be improved by way of marketing of raw material. The results would be beneficial especially from the point of view of cultivation of *T. terrestris* as it has numerous medicinal uses and great demand by Ayurvedic industries in India.

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