Chapter - I

Review of Literature

A) Soil Salinity Problem

1. Process of soil salinization

All soils contain salts, but the saline soils contain excess of these salts. Saline soils were originally called "White alkali" soils. They were also called as usar land and "Khar land" by Indian. Russians designate them as Solonchak soils. Now the term is gradually changing to saline soils. Soils are classified as saline if the solution extracted from a saturated soil paste has an electrical conductivity value of 4 or more mmhos/cm at 25^{o}C. This information is obtained on a special salt bridge, patterned after a common wheatstone bridge. The amount of exchangeable sodium in saline soils is low, being less than 15%; as a consequence, the pH is below 8.5.

Although salinity is a common phenomenon and one of the basic features of arid and semiarid regions, it is also occurring in irrigated tracts. Some of the salts reach the crust of the earth from such sources as cosmic dust and volcanic activity. But at present are mainly soluble salts added from three major sources

i) Marine sources
ii) Lithogenic sources
iii) Anthropogenic sources.

i) Marine sources :

Frequent volcanic eruptions release considerable quantities of soluble salts into the atmosphere. Vast amounts of chlorine and sulfur from this source have accumulated during the ages in the oceans, either directly by underwater volcanic action. Precipitation of volcanic ash, dissolution of gases, or indirectly via streams and rivers which wash soluble salts off the continents. However, salts were not left evenly distributed. After continuous cycling for long geological eras, distribution of various elements and compounds between different localities had distinctively took place. While the more soluble salts of chlorine were leached and accumulated mostly in the oceans, over half of the compounds containing sulfur, presently found in the geochemical cycle, precipitated and concentrated in rocks sedimented under seawater. A small quantity of sulfur can also be found ir igneous rocks.

Salts of marine origin are transported to the continents and deposited there in three major ways :

a) Cyclic salts
b) Infiltrating salts
c) Fossil salts

a) Cyclic salts :

These salts are brought inland from the sea in the form of windborne sea spray, and precipitated by rainwater. Such salts are later redistributed or leached back into the ocean by the common drainage systems. It has been well known for a long time that atmospheric precipitation contain varying amounts of soluble salts. After being intercepted and precipitated, salts percolate through the soil and are washed into drainage systems and ground water. Thus, salts of maritime origin eventually form the primary and major source of salts of rivers and wadies (Anderson, 1945) or of groundwater (Loewengart, 1958).

Frequent tropical cyclones also pour large masses of seawater over the continent, thus increasing salinization. However, since cyclones usually occur in humid regions and are accompanied by heavy rains, salts are also rapidly leached away. Teakle (1937) found that rainwater near the costs of Australia had 15-50 ppm NaCl, whereas rainwater sampled further inland had only 4-20 ppm NaCl. Salts are carried inland as far as 1000 Km or more. Wind intensity and roughness of the sea influence the amount of airborne droplets and consecuently amount of salt deposition in ferrestrial habitats. Large airborne droplets are usually precipitated within a distance of less than 1500 m from the coast (Yaalon and Lomas, 1970). Chloride salts are mainly transported as droplets, but sometimes they may be carried in a solid form of minute crystals. The small size of salt particles (0.1 - 10 μ) led Cassidy

(1971) to believe that such particles are capable of entering leaf stomates. He also suggested that entry of such aerosols into leaves may be the cause of impaired plant growth on coastal habitats.

b) Infiltrating salts :

Underground infiltration of seawater or other sources of saline water into the capillary fringe of neighbouring habitats constitute a continuous supply of salts to such habitats. Surface evaporation causes an increase in concentration of the incoming brine and raises the concentration of salts on the soil surface. The amount of salt contributed by this source to salinization of terrestrial habitats is high in arid regions and negligible in humid ones (Waisel 1972). Also the overuse of wells near seacoasts increases infiltration rates of seawater into the underground water reservoirs and causes their salinization.

c) Fossil salts :

It is an important source of salts on certain sites, but usually salts of this source are limited to a few habitats. Such salts have accumulated in the past on coasts of ancient seas, on sites of salty lakes, or during past penetrations and local accumulation of seawater. Saline shales of the Colorado, plateau of the United states can serve as an example of the effects of sea inundation in the past. Underground waters which presently flow through such deposits of sodium chloride dissolve the salt and carry the brine up to the soil surface and into the plant root zone. Saline groundwaters from such sources occur extensively in arid regions. Salinization of groundwater has even increased since humans have interfered with natural salt and water balance, i.e. destruction of native vegetation or large-scale irrigation (Eriksson, 1958).

ii) <u>Lithogenic sources</u> :

There are marked differences between distribution of chlorine and sulfur in nature. Because of its high solubility, chlorine occurs in all rocks in very low quantities. While a large portion of the total amount of sulfur released in the past, into the oceans was precipitated into sedimentary rocks. Chlorine is primarily found in rocks as chlorides of the alkali metals. Presumably chloride is not incorporated into rock crystals, but is precipitated as intercrystal penetrations. In such a location and form, chlorides can migrate readily within homogeneous rocks as well as between various rock layers (Goldberg, 1958). Low amount of chloride and relatively high amounts of sulfur are found in rocks.

The extent of salinization of groundwater and soils by chloride or sulfate from rock sources depends very much on the rate of rock weathering which varies markedly in different climates and regions. The rates of rock weathering in the semiarid climate of the Mediterranean region vary between 10 mm per millennium on the flatlands and 50 mm on steep slopes. If the chloride content of the average dominant rocks is taken as 0.04%, the addition salt form this source is limited to 16-80 gm/1000 m^2/year. Sulfur is released from rocks in relatively greater quantities than are chlorides. Weathering of rocks also releases large amounts of carbonates of calcium and magnesium. Both divalent cations play an important role in control of salinization of soils. However, as rocks generally are very low contributors of salts, such sources can hardly account for salinization.

Under specific conditions weathering of saline rocks may also contribute large amounts of soluble salts. According to Bocquier (1964), such sources are primarily important for local formation of salines in inland habitats. The oceans do not supply all of the salts found in rainwater. Salt containing dust from terrestrial sources also influences the chemical composition of rainwater (Yaalon and Katz, 1962).

In regions receiving 500 mm mean annual rainfall, at an average concentration of 10 ppm chloride, an annual addition of approximately 8 Kg NaCl/1000 m^2 may be expected. Dew deposits also contain high quantities of salts. e.g. Yaalon and Ganor (1968) showed that dew droplets had a high concentration of calcium, bicarbonate, and sulfate ions. Nevertheless, because of the composition of the salts, it seems that salt precipitation in dew is of terrestrial, rather than of marine, origin. Besides dew, fogs also carry inland large quantities of salts. Considerable amount of salts are carried by this means in South America (Eriksson, 1958).

iii) Anthropogenic sources :

Since ancient times, human activity has been adding large quantities of soluble salts to agricultural lands. In some areas irrigation with unsuitable water under the high evaporative conditions of arid or semiarid climates and practice of improper agrotechnical procedures have resulted in deposition of large quantities of salts in upper soil layers. For example irrigation with water from the Jordan River (approx. 500 mg/liter soluble salts) at an annual rate of 1000 m^3 water per 1000 m^2 land, adds at least a net 500 gm of salts per square meter to the soil. The ground waters of arid regions usually contain considerable quantities of soluble salts. If the water table is high, large amounts of water move to the surface by capillary action and are evaporated, leaving an everincreasing accumulation of soluble salts. This process of accumulation of soluble salts makes the soil highly impregnated with salts and only saltresistant crops can grow. The faulty irrigation practices also cause salt accumulation. The excessive application of water resists the ground water level sufficiently to permit concentration of salts from saline ground water through evaporation. The saline soils also develop when the use of irrigation water is erratic i.e. flooding at one time followed by intense drought. When the total supply of water limited, this also leaves the salt in the root zone. The saline soils also result when poor drainage keeps the salts in the surface soil and prevents the leaching of salts. Electric power plants, metal smelters and automobile fumes may also add considerable amounts of pollutants, mostly of SO_2 and to limited areas. Cement factories also spread annually thousands of tons of salts in their surroundings. Although the major contribution of such factories is in the form of calcium carbonate and calcium hydroxide, the added salts are still of local importance.

Urban use of water also results in increase of salinity. Measurements made in Ohio (Bunch and Ettinger, 1964) and in Israel (Rebhun, 1965) indicate that the average increase in water salinity in one single cycle of urban use is approximately 325 mg/liter. Reuse of city sewage evidently causes considerable salinization of groundwater (Bagley, 1967).

Eriksson (1958) summarized the sources and gross composition of salts deposited on continents

Source	Element	
	Chloride	Sulfur
Human activities		
Production	2.3	1.0
Combustion	0.01	0.6
Weathering of rocks	0.04	0.44
Volcanic (juvenile)	0.2	0.02
Total known sources	2.6	2.1
Cyclic salts	12.9	9.0
Total salt additions per annum (Kg/ha)	15.5	11.1

2. Soil salinity problem in India

It is estimated that about 12 million ha of land have been affected by salinity and of alkalinity conditions in India.

Grouping of the estimated salt affected areas in India is given below (Sharma and Gupta, 1986)

Area	States	Million ha
Indo-Gangetic	Uttar-Pradesh, Haryana, Delhi, Punjab	4.0
Alluvial plains	Bihar, and parts of Rajasthan	
Medium and deep	Madhya Pradesh, Rajasthan, Gujarat	4.0
Black soil	Maharashtra, Karnataka and Andhra	
Arid and Semiarid	Rajasthan and Gujarat	1.0
Coastal	Gujarat, West Bengal, Orissa, Kerala, Tamilnadu, Andhra Pradesh and Maharashtra	[illegible].0

Soil salinity is a serious problem in areas along Indias 6000 Kms of coastal line. This area extends from seashore to inland ranging in width from a few kilometres to about 50 Kms. The extent of soil salinity and the spread of these saltaffected soils from seashore to inland are closely associated with the ingression of sea water specific to depth along with spread through estuaries situated in the region. The tides manifest the regular rise and fall of the water level in the estuarine channels and creeks spreading the saline water over the land as the tidal flow repeatedly inundates the land and impregnates the soil with salts. Whereas the coastal areas at some location are protected by embankments which stop the ingress of sea water, there are areas where the sea water enters through estuaries and inundates the lands.

In general the coastal saline areas in the country receive high rainfall from June to September except those in the Kutch region of Gujarat and Tamil Nadu (the last receiving high rain from October to December). The higher evaporation into the atmosphere during March-June, accentuates the movement of salts from the lower profile of the soil due to capillary rise, increasing salt concentration in the surface soil and rendering it unfit for sustaining any vegetation. Thus the salinity status of the soil varies with the season. The cyclonic storms, often accompanied by high tides, cause the sea water to inundate large areas inland and thus aggravate the salinity problem. As the monsoon advances, the rain water flushes the saline soil bringing a dilution effect and reducing the salinity. When the land gets flooded, and then drained, certain amount of salt is carried away to the sea.

In general, the soils are medium to heavy textured with sodium chloride as the dominant soluble salt, except in Kerala where the soils also contain large quantities of sodium sulphate(Pande and Reddy, 1988). The salt-affected soils in the high rainfall areas tend to be slightly acidic (pH less than 6.5) while those in the low rainfall regions are neutral to alkaline (pH 7.5 to 8.0). The saltaffected coastal soil in Kerala are acid sulphate and their pH is much lower, ranging between 2.5 and 5.0. The groundwater is encountered within 1 to 2 m below the ground level in the pre-monsoon season in most of the coastal areas. The salinity of water ranges between 2 to 20 mmhos/cm. The groundwater rises to the surface when the underground drainage ceases during the monsoon and as a result the water accumulates on the soil surface sometimes to a depth of 50 cm or more. Marked seasonal variations in the salinity of seawater and estuarine water encroaching coastal saline soils has been noticed by several workers (Rao, 1965, Jamale, 1975, Jagtap and Untwale, 1981, Sengupta and Naik, 1981).

The distribution of coastal saline soils in India has been summarized by Yadav et al. (1983) and Bandopadhyay and Abrol (1984) in following table.

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States (Districts)	Area million ha	Rainfall (mm)	
		June to Sept.	Oct. to Dec.
West Bengal (24 Parganas North, 24 Parganas South, Midnapur East, Howrah)	0.820	1325	177
Gujarat (Surat, Valsad, Bharuch, Kaira, Ahmedabad, Bhavnagar, Surendranagar, Amreli, Rajkot, Jamunagar and Junagarh)	0.714	930	30
Kutch region			
Orissa (Balasore, Cuttack, Puri, Ganjam)	0.400	1140	180
Andhra Pradesh (Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam and Nellore	0.276	570	330
Tamil Nadu (Chengelput, South Arcot, Tanjavore, Ramnathapuram, Tirunelvely)	0.100	310	480
Karnataka (North and South Canara)	0.086		
Maharashtra (Ratnagiri, Sindhudurg, Raigad, Thane)	0.064	2700	130
Kerala (Ernakulum, Alleppey, Cannanore and other coastal districts)	0.026	2010	550
Goa	0.018		
A and N Islands	0.015		
Pondicherry	0.001		
Mangrove	0.574		
	3.094		

B) HALOPHYTES

1. Introduction :

The term halophyte has been interpreted in different ways by different workers. Chapman (1960) describes halophytes as "salt-tolerant plants," Fernald (1950) says they are plants "growing in saline soils", and Dansereau (1957) opines that a halophyte is "a plant that grows exclusively on salt soil; e.g., all species of *Salicornia.*" Other definitions include plants of salty or alkaline soils (Correll and Johnston, 1970); plants that can tolerate the concentrations of salts found in saline soils (Oosting, 1956); and plants tolerant of various mineral salts in the soil solution, usually sodium chloride (Lawrence, 1951). According to Waisel (1972) plants which grow and complete their life cycle in habitats with high salt content are called salt plant or halophytes. He further argues that the term is reserved only for plants which appear in salty habitats constantly and specifically. According to Flowers *et al*. (1986) halophytes are plants found growing under naturally saline conditions. Aronson (1989) has taken tolerance to electrical conductivity measuring at least 7.8 ds m^{-1} during significant periods or the plants entire life as a primary criterion for considering the plant as a halophyte.

2. Classification of Halophytes :

There are different approaches towards classification of halophytes and accordingly different systems of classification have been proposed (Stocker, Iversen, Chapman, Van Eijk, Tsopa, Weissenbock, Kreeb, Hamer *et al*., Steiner, Adriani, Henkel and Shakhov). Waisel (1972) has made an attempt to unite the plant salt relationships into one scheme and to put more stress on salt-resistance mechanisms and on internal rather than on external salt relationship. His system of classification is given below :

I] Euhalophytes : a) Salt-requiring halophytes :

i) Obligatory halophytes :

plants dependent upon salts for their survival, e.g., *Salicornia* species and various bacteria and algae.

ii) Preferential halophytes :

Plants whose growth and development are improved in the presence of salts e.g. *Arthrocnemum* species, *Aster* species; *Nifraria* sp., *Salicornia* sp., *Suaeda* sp.

b) Salt-resisting halophytes :

i) Salt-enduring halophytes (salt tolerant):

plants enduring a high protoplasmic salt content, e.g. *Suaeda monoica*

ii) Salt-excluding halophytes :

plants accumulating salts in special hairs, e.g. Atriplex sp.

Plants secreting salts from their shoot, e.g. Aeluropus sp., Limonium sp., Tamarix sp.

plants retransporting salts from the shoot into the root, e.g., Salicornia sp.

iii) Salt-evading halophytes :

plants evading salt uptake, e.g., Rhizophora sp.

Plants evading salt transport into the leaves, e.g., Prosopis farcta

II] Pseudohalophytes :

i) Salt-avoiding plants :

Ephemers

Niche plants.

3. Economic importance of Halophytes :

It is now very well realised that several halophyte species possess great economic potential. As abundant source of timber, firewood and charcoal, as well as of tannin and many minor products, mangroves have been exploited quite extensively in virtually all the tropical coastal regions and estuaries where they occur. Another group of halophytes important world wide for forage and fodder in continental and coastal desert region, is the large group of chenopodiaceae commonly called salt bushes. Some halophytic species like Beta vulgaris, Zostera marina and Distichlis palmeri are also cultivated as food crops. The young leaves and shoots of Batis maritima, Portulaca oleracea, Tetragonia tetragonoides, Salicornia spp., and Suaeda torreyana have also all been used for salads and pickles in various parts of the world (Aronson, 1985). Salvadora oleoides and S. persica yield edible fruits rich in oil and fat. Juncus-based rushes industries are in operation in Egypt and Israel. Halophytes of agricultural or horticultural value are also being increasingly used for land reclamation. Many halophytes have been selected for amenity planting and landscaping in arid and semi-arid regions where saline or brackish water is available more readily or cheaply than fresh water. In the Southern part of Israel, salt-tolerant ornamentals have been used for gardening and landscaping for over two decades (Pasternak et al., 1984a).

4. Halophyte survey and leguminous halophytes :

There have been few attempts to list different halophytic species. Duncan (1974) tried to make a list of vascular halophytes of the Atlantic and Gulf coasts of North America North of Mexico. His list of halophytes includes 347 species in 177 genera and 75 families. In her listing of 550 halophytic species in some 220 genera and 75 families, Mudie, (1974) demonstrated the wide range of wild halophytic germplasm. Aronson (1989) has prepared a data base of halophytes of the world. He has reported 1560 species of halophytes belonging 550 genera and 117 families. According to him following species of Leguminosae can be regarded as halophytic.

A) Sub-family - Caesalpiniaceae :

1) *Caesalpinia bonduc* (L.) Roxb.
2) *Caesalpinia crista* L.
3) *Cassia acanthoclada* Griseb.
4) *Cumingia philippinensis* Vidal
5) *Cynometra iripa* Kostel.
6) *Cynometra ramiflora* L.
7) *Inocarpus edulis* Forster
8) *Intsia bijuga* (Colebr.) O.Kuntze
9) *Intsia retusa* (Kurz.) O.Kuntze
10) *Mora oleifera* Ducke
11) *Pithecellobium lanceolatum* Ducke
12) *Pithecellobium umbrellatum* (Vaili) Brh.

B) Sub-family - Mimoseae :

1) *Acacia cornigera* (L.) Willd.
2) *Acacia cyclops* A. Cunn. ex G. Don.
3) *Acacia jacquemontii* Benth.
4) *Acacia leucophloea* (Roxb.) Willd.
5) *Acacia nilotica* (L.) Del.
6) *Acacia rostellifera* Benth.
7) *Mimozyganthus carinatus* (Griseb.) Burk.

8) *Prosopis articulata* S. Watson

9) *Prosopis chilensis* (Mol.) Stuntz.

10) *Prosopis cineraria* (L.) Druce

11) *Prosopis farcta* (Sol. ex Rus.) Macbr.

12) *Prosopis juliflora* (Swartz.) Dc.

13) *Prosopis nigra* (Griseb.) Hier.

14) *Prosopis pallida* (Willd.) H.B.K.

15) *Prosopis reptans* Benth.

16) *Prosopis ruscifolia* Griseb.

17) *Prosopis strombulifera* (Lam.) Benth.

18) *Prosopis tamarugo* F. Phil.

19) *Prosopis torreyana* L. Benson

20) *Prosopis velutina* Wooton.

C) Sub-Family - Papilionaceae :

1) *Aganope heptaphylla* (L.) Pohill

2) *Alhagi maurorum* Medil

3) *Canavalia maritima* (Aubl.) Thouars

4) *Canavalia obtusifolia* (Sw.) DC.

5) *Canavalia rosea* (Sw.) DC.

6) *Dalbergia amerimnion* Benth.

7) *Dalbergia caudenatensis* (Dennst.) Prai

8) *Dalbergia ecastophyllum* (L.) Benth.

9) *Dalbergia menoides* Prain.

10) *Dalbergia sissoo* Roxb.

11) *Daviesia hakeoides* Meissn.

12) Derris trifoliata Lour.

13) Drepanocarpus lunatus G.F.W. Meyer

14) Erythrina herbacea L.

15) Erythrina variegata L.

16) Geoffroea decorticans (Gill.) Burk.

17) Hedysarum carnosum Desf.

18) Indigofera spinosa L.

19) Inocarpus fagifer (Park.) Fosb.

20) Lathyrus littoralis (Nutt.) Endl.

21) Lathyrus palustris L.

22) Lotus creticus L.

23) Lotus cytisoides L.

24) Lotus halophilus Boiss.

25) Lotus jolyigi Batt.

26) Lotus nuttalianus Greene.

27) Lotus preslii Cen.

28) Lotus tenuis White and Kit. ex Willd.

29) Medicago litoralis Rohde ex Loisel.

30) Medicago marina L.

31) Millettia hemsleyana Prain

32) Muellera frutescens L.f.

33) Muellera monoliformis L.f.

34) Ormocarpum verrucosum Beaur.

35) Pongamia pinnata (L.) Pierre

36) Pongamia velutina (White) Vord.

37) Pterocarpus indicus Willd.

38) *Pterocarpus officinalis* Jacq.

39) *Pterocarpus draco* L.

40) *Sophora tomentosa* L.

41) *Tephrosia purpurea* (L.) Pers.

42) *Trifolium maritimum* Hudson

43) *Trifolium resupinatum* L.

44) *Trifolium tomentosum* L.

45) *Trifolium wormskjoldii* Lehm.

46) *Vigna marina* (Burm.) Merrill

Besides above legume species, following species have been also regarded as halophytic by some workers (Mudie, 1974; Chapman pers., 1972; Haywad, 1954; Darlington and Wylie. 1955; Firmin, 1968; Sen *et al.*, 1982).

1) *Anthyllis vulneraria* L.

2) *Derris ecastophyllum* (L.) Benth.

3) *Derris sinuata* Thw.

4) *Dichrostachys glomerata* Hutch. and Dalz.

5) *Lotus corniculatus* L. var. tenuifolius

6) *Medicago hispida* Gaertn.

7) *Melilotus indicus* (L.) All.

8) *Prosopis pubescens* Benth.

9) *Trifolium fragiferum* L.

10) *Trifolium repens.* L.

11) *Sesbania bispinosa* (Jacq.) W.F.Wight.

It is evident from the foregoing account that about 90 species of family leguminosae possess the great potential of salt tolerance and hence may be regarded as halophytes. This is relatively a very small proportion when the total number of species in family leguminosae is taken into consideration. Further among these halophytic species only few species are really economically important.

C) ABOUT DERRIS

1. Introduction

The generic name *Derris* is derived from Greek, word derris "leather covering", in reference to the tough seed pods. The genus *Derris* belongs to family leguminosae and the subfamily papilionoideae. In the year 1958 it was named as *Brachypterum* but later the name *Derris*, was conserved as it was the earlier name published by Lour. in the year 1790. The genus *Derris* has been separated into four sections -

a) *Brachypterum* Wt. and Arn.

b) *Derris* Lour

c) *Dipteroderris* Benth.

d) *Paraderris* Miq.

There are 120 species of *Derris*. Of these 23 species are found in India and nine species are endemic in India (Thothathri, 1982). The *Derris* species found in India are listed below :

1) Derris robusta (Roxb. ex DC.) Benth.
2) D. pseudo-robusta Thoth.
3) D. ovalifolia (Wt. and Arn.) Benth.
4) D. elegans Benth.
5) D. canarensis (Dalz.)
6) D. accuminata Benth.
7) D. cuneifolia Benth.
8) D. macrocarpa Thoth.
9) D. elliptica (Wall.)
10) D. lushaiensis Thoth.
11) D. monticola (Kurz)
12) D. secunda Baker
13) D. hainesiana Thoth.
14) D. thothathrii Bennet
15) D. heyneana (Wt. and Arn.)
16) D. kanjilalii Sahni et Naithani
17) D. marginata (Roxb.) Benth.
18) D. ferruginea (Roxb.) Benth.
19) D. andamanica Prain.
20) D. brevipes (Benth.)
21) D. benthamii (Thw.) Thw. Enum.
22) D. scandens (Roxb.) Benth.
23) D. trifoliata Lour.
24) The synonyms for Derris scandens are :

a) Dalbergia scandens Roxb.
b) Brachypterum scandens (Roxb.) Bemth.

c) *Derris timoriensis* (DC.)

The synonyms for *Derris trifoliata* are :

a) *Robinia uliginosa* Willd.

b) *Galedupa uliginosa* Roxb.

c) *Derris uliginosa* (Willd.) Benth.

d) *D. heterophylla* (Willd.) Backer

The Vernacular names for *D. scandens* are :

Hindi	-	Gonj
Bengali	-	Noalata
English	-	Hog Creeper
Kanada	-	Handiballi
Malayalam	-	Ponnam valli, Muyal Valli, Nula valli
Oriya	-	Kamocho, Mohaguno
Gond	-	Golari
Punjabi	-	Gunj
Tamil	-	Thirudencodi, Tirani, Anaikkattu, Kodippungu, Puliyankodi
Telgu	-	Nalla tige, Cheratalibadu, Chirukatige, Mottasirili, Suruli.

The vernacular names for *D. trifoliata* are

Bengali	-	Panlata
Marathi	-	Kirtana
Telgu	-	Tigekranuga, chirathelathige, Nallatige

2. Distribution :

Most of the *Derris* species are found in tropical Asia and few are in Africa and America. *Derris scandens* is found to be distributed throughout India, Burma, Sri Lanka, Bangladesh, Pakistan, Malesia, Thailand, Australia, and South China. *Derris trifoliata* has been reported from India, West Bengal, Burma, Sri Lanka, Bangladesh, Malesia, North Australia, Vietnam Formosa, China, E.Africa, Madagascar.

In India *D. trifoliata* has been reported from Assam, W. Bengal, Orissa, Andaman and Nicobar Islands, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa and Maharashtra. All *Derris* species tolerate a wide range of soil conditions from fertile loams to barren area. Well drained soils, a well distributed rainfall and tropical climate are preferable. Wild species occur as woody climbers in tidal areas, mangrove swamps, lowland forests, secondary jungles or brushwood, and along muddy banks of rivers.

According to Thothathri, *D. trifoliata* is the only species of the genus growing in mangrove swamps and creecks and also in tidal forests. Walsh (1974) has studied distribution of this species in the West coast and East coast of India; and according to him the distribution is as follows :

a] West coast

Kathiawar Peninsula	Bombay region	Kerala coast
0	Not common	Not common

b] East coast

Cauvery delta Tamil Nadu	Krishna and Godavari Andhra Pradesh	Mahanadi delta Dharma	Gangetic delta India only
Common	Common	Not common	Not common

c] Andaman and Nicobar islands - Not common

Although Thothathri (1982) has mentioned that D. trifoliata is the only halophytic Derris species, there are few reports which indicate that some other Derris species are also halophytic. These include D. ecastophyllum (L.) Benth. (Darlington and Wylie 1955) and D. heptaphylla (L.) Merr. (Chapman, 1974). According to Untawale (1979) D. trifoliata and D. pentaphylla are found in the mangrove swamps of Goa and elsewhere. Joshi and Bhosale (1982) reported that D. trifoliata is common in the estuarine vegetation at Ratnagiri, Ganapatipule, Deogad, Mumbra and Bhatya.

Caratini et al. (1973) made study of mangrove vegetation in Pichavarum. They noticed three principal vegetation zones, Rhizophora zone, Avicennia zone and Back mangrove. The Rhizophora zone was developed in those regions which are permanently immersed at the low and high tides. Its width never exceeded 10 meters in the locality. The dominant stratum principally consisted of Rhizophora apiculata and R. mucronata. The secondary stratum comprised of Bruguiera cylindrica, Ceriops decandra, Aegiceras corniculatum, Lumnitzera littorea, Dalbergia spinosa, Derris trifoliata, etc.... and rarely Sonneratia apetala and Avicennia officinalis. Radhakrishnan (1985) recently employed the technique of aerial photography to study the mangrove distribution along the central west coast (Achara, Maharashtra). Her finding are depecited in table (The species names listed, in Table are as follows i) Avicennia officinalis, Avicennia marina, Rhizophora mucronata, Bruguiera gymnorrhiza, Sonneratia alba, Sonneratia caseolaris, Excoecaria agallocha, Aegiceras corniculatum, Derris trifoliata, Clerodendron inerme).

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Zone	Area (ha)	% of Total Mangrove Area	Distance from Mouth (Km)	Distance to which Extend (Km)	Mangrove species Found in zone
Avicennia zone	28.76	38.70	1.40	2.60	A. officinalis A. marina R. mucronata and B.gymnorrhiza
Sonneratia zone	15.72	21.20	1.60	2.60	S. alba S. caseolaris R. mucronata A. officinalis
Rhizophora zone	14.80	19.80	0.95	1.50	R. mucronata, A. officinalis S. alba
Excoecaria zone	9.08	12.20	2.60	3.14	E. agallocha, A. corniculatum, D. trifoliata, B. gymnorrhiza, C. inerme, R. mucronata, A. officinalis, and S. alba S. caseolaris
Fringing	3.07	4.10	1.70	4.70	E. agallocha, D. trifoliata, R. mucronata, A. officinalis, A. corniculatum, C. inerme and S. alba.
Scattered Patches and Inlet	2.98	4.60	-	-	Varies

3. Morphology :

The genus Derris has been described by Allen and Allen (1981) in following words: Vines, woody, perennial or shrubs, usually twining, some times creeping, rarely trees. Leaves imparipinnate, stipulate, without tendrils or stipels; leaflets 3-many. Flowers small, profuse, showy, violet, pink, or white usually fascicled, in axillary or terminal racemes or panicles; bracts small, caducous; calyx subtended by 2 basal, often caducous bracteoles; tube truncate or cupular; teeth indistinct or very short, lowermost tooth often longest; standard obovate or orbicular, sometimes with inflexed basal ears; wings oblique-oblong, slightly adherent to the incurved keel above the claw; stamens monadelphous, all connate into a tube, or vexillary stamen free at the base; anthers versatile; ovary sessile or short-stalked, hairy, ovules 2-many; style slender, curved, glabrous above; stigma small, terminal. Pod brown, leathery, orbicular or elongated, flat, rigid, narrowly winged along 1 or both sutures, indehiscent; seeds 1-6, flat, kidney-shaped or orbicular.

The morphological pecularities of D. scandens are narrated by Thothathri (1982) in following words: woody climbers; stem attaining 30-40 cm in diam. Leaves 7.0 - 18.5 cm long; leaflets oblong to obovato-oblong, 4.0 - 8.5 (-10) X 1.5 - 3.5 (-4) cm, base rounded to cuneate, apex retuse, glabrous above, puberulous below; stipels linear.

Racemes (Fig.1a) axillary and terminal, at times branches, 18-38 cm long; nodes of racenes tumid with a cluster of pedicellate flowers borne on short stalks. Corolla white or pink; Vexillum ovato-orbicular, 0.9 cm. staminal sheath 0.9 - 1.0 cm. long. Pistil 0.9-1.0 cm long; ovules upto 8, pods narrowly oblong, 3.5 - 12.0 X 1.0 - 1.6 cm, reticulately veined, adpressed with minute, silky hairs, winged on the dorsal suture; seeds 1-5 reddish brown, 8 x 5 mm.

The morphological pecularities of D. trifoliata Lour. have been described by Thothathri (1982) in following words :

Scandent shrubs to climbers. Leaves 10.4 - 25.0 cm long; leaflets 3-5, 4-5 - 13.0 X 2.5 - 6.4 cm, rounded at base, shortly acuminate, subcoriaceous; petiolules 3-5 mm long. Racemes axillary (Fig. 1b), 5-25 cm long, nodes tumid bearing one or more flowers, Flowers 1.0 - 1.2 cm; pedicels 2-3 mm long. Calyx truncate, 3 mm. Corolla rose-pink; Vexillum ovate to ovato-orbicular, 1.0 - 1.1 cm long. Staminal sheath 1.0 - 1.1 cm long. Pistil 0.9 - 1.0 cm long, ovary narrowly oblong; ovules 7-8. Pods 2.0 - 5.2 X 2.5 - 3.8 cm, glabrous, reticulately veined, distinctly winged on the dorsal suture; seeds 1.2, ovato-orbicular, 1.0 x 1.5 cm, reddish brown to black.

Fig.1. Inflorescence bearing twigs of i) *Derris trifoliata* and ii) *D. scandens*.

(i)

(ii)

4. Anatomical Studies :

Anatomical studies of different plant parts of different *Derris* species along with other papilionaceae members have been made by several workers, from time to time and this work has been summarized by Metcalfe and Chalk (1957-79) in their exaustive volume on Anatomy of Dicotyledons. Some of the mentions about *Derris* anatomy, made in their volumes are coated below :

a) Root anatomy :

Russell (1972) has studied root anatomy of *D. elliptica*. Metcalfe and Chalk (1957-79) described the anatomical features of the economically important Tuba root (*D. elliptica*) in following words :

Roots upto 1 cm. in diameter with greyish-brown bark, with shallow, sinuous, longitudinal furrows. Older roots partly encircled by transverse ridges. Xylem, on a freshly cut transverse surface, cream to pale yellow; vessels easily visible except at the centre. Cork consisting of up to about 12 layers of cells; outer cells dark reddish-brown; inner ones lighter in colour and thin walled. Groups of stone cells and numerous secretory cells with shining golden-brown contents present beneath the work. Phloem stratified into tangential zones of hard and soft tissue, and broken up into wedge-shaped strands with enlarged distal ends of the rays.

Phloem fibres very thick-walled, average diameter about 10 µ. Secretory cells containing resin and rotenone, frequent between the groups of phloem fibres. Xylem including vessels of 2 distinct sizes. Larger vessels elliptical to circular in transverse section, diameter 110 X 90 - 210 X 170 µ but usually about 180 X 155 µ, mostly solitary or occasionally accompanied by 1-6 much smaller angular vessels generally about 27 X 32 µ in diameter. Small vessels also occur arranged in radial rows or cluster of 3-6. Vessel members mostly 140-190 µ long. Perforations simple. Pits alternate, elliptical to polygonal, about 6 µ broad, with horizontal slit-like borders; distinctly vestured. Ground tissue of the xylem consisting mostly of storied parenchymatus cells filled with starch, a few containing resin or rotenone compact strands of fibres occur in the parenchymatus ground-mass, each strand consisting of 2-50 very thick walled elements about 10 µ in diameter and surrounded by a sheath of cells each containing a solitary crystal embedded in thickenings of the inner tangential walls. Rays homogeneous, 1-6 cell wide

b) Young stem anatomy :

The following pecularities have been reported by Metcalfe and Chalk (1957-79):

i) A. composite and continuous ring of sclerenchymatus pericycle.

ii) A closed cylindrical xylem with vessels frequently blocked with a dense black secretion.

iii) Presence of cortical vascular bundles.

iv) Presence of secretory elements that is secretory cells and secretory cavities.

C) Wood anatomy :

i) Five to twenty vessels per square meters.

ii) Vessels confluent forming irregular bands or the matrix for tangential bands.

iii) Presence of homogeneous rays.

iv) Presence of anomalous structure consisting of successive layers of xylem and phloem repeating the primary structure of stem separated by tangential bands of conjunctive parenchyma (Solereder, 1908).

d) Leaf anatomy :

Following peculiarities of leaf anatomy have been recorded by Metcalfe and Chalk (1957-79) :

i) Stomata are confined to lower surface.

ii) Lower epidermis papillose or sub-papillose in some species of Derris.

iii) Central layers of mesophyll occupied by cells containing little chlorophyll and often but not invariably, filled with tanniniferous contents which are coloured brown in dried materials.

iv) Presence of secretory cavities of various types usually appearing as transparent dots.

v) Presence of small rod shaped crystals (styloids) in palisade tissue.

vi) Presence of small crystalline grains or prisms.

5. Cytological studies :

The cytological studies of Derris species have been attempted by several workers. These studies have revealed that the chromosome number (n) in Derris species varies from 10 to 13 (Darlington and Wylie, 1955). The chromosome number (n) in D. scandens was found to be 13 while in D. trifoliata it was found to be 11 (Toxopeus, 1952; Mallick and Ghosh, 1968).

6. Ecophysiological studies :

Sidhu (1963) analysed major inorganic constituents in the leaves of Derris uliginosa along with other mangrove species. He divided mangrove species into three catagories based on sodium content of leaf

a) Species with more than 5% sodium: A. marina, Salvadora persica.

b) Species with 3-5% sodium : A. alba, Lumnitizera racemosa, *Ceriops candolleana* and *A. ilicifolius*.

c) Species with 1-3% sodium : *A. officianlis*, *R. mucronata*, *S. Apetala*, *B. Caryophylloides*, *A. corniculatum*, *Eleopodendron inerme*, *Exocoecaria agallocha*, *D.uliginosa*.

Kotmire and Bhosale (1979) made inorganic analysis of the mature leaves of *Derris uliginosa* along with other mangroves growing in Deogad and Mumbra Creecks. Apart from the above two attempts not much, is understood regarding the ecophysiological aspects of various *Derris* species.

7. Economic importance of *Derris* species :

The importance of Derris species has its origin in the primitive practice throughout southeast Asia, South America, Philippines, East Africa, and the South Pacific Islands of throwing soaked or crushed plant parts into streams for the purpose of stupefying fish. The fish may be eaten with impunity. *Derris* species were among the earliest plants used for this purpose. Concurrent with the use of *Derris* species for fish-stupefication was the incorporation of macerated plant parts and decoctions in arrow poisons and in shampoos to eliminate lice.

Derris insecticides are extensively employed for pest control in horticulture and agriculture, and in poultry and animal husbandry. They are applied in the form of dusts, sprays, dips, baits and aerosols. Finely ground roots mixed with talc, Kaolin, fullers, earth and gypsum are used as dusting powders (rotenone content 0.75%). Mixed with suitable spreader and water they are employed as sprays; with various diluents and containing 0.12 - 0.35 % rotenone are effective against a variety of agricultural and horticultural insect pests. Derris has been employed in the control of earth-worms in lawns. It has also been employed in the preparation of moth-proofing compounds (Holman, 1937). Derris powders are effective in controlling and eradicating external parasites of animals including fleas, lice, dog, ticks, cattle grubs, sheep keds, pigeon flies and sarcoptic, demodectic and ear mange mites of dogs and household insects (Gayar and Shazli 1968). Derris insecticides deteriorate when exposed to sunlight and air. Spray fluids lose their activity more rapidly than dusts. Protection against deterioration is afforded by the use of anti-oxidants. When stored under cool and dry conditions, Derris roots retain their activity for considerable periods of time. The roots of D. elliptica and D. malaccensis constitute the Derris or Tuba Root of commerce used as agricultural and horticultural insecticide and fish poison. These 2 species are cultivated on a commercial scale in Malava, Sumatra, Java, Sarawak, Philippines, Tanganyika, Belgian Congo and on an experimental scale in India. D. ferruginea grows wild in some parts of India and is the source of the Indian Tuba Root.

Chemical studies aimed at isolating the insecticidal principle began in the late 1800s. In 1902 Nagai isolated from *D. chinensis* Benth. colourless crystals melting at 163°C, which were called rotenone. Rotenone exists as discrete globules of rotenone containing resin in parenchyma cells in pith, medullary rays and in irregularly dispersed cell groups in the cortex and bark. It is absent in the corky layer of the bark and in the vessels, fibres of the wood and the bast. Rotenone does not occur in the cells containing starch. Rotenone first makes its appearance in the secondary cortical cells opposite the protoxylon in *D. elliptica* roots between the 5th and 6th weeks of plant growth (Worsley and Nutman 1937). Thereafter it spreads in scattered groups throughout the xylem parenchyma and cortex. The rotenone containing cells are morphologically unspecialised. An increase in number of these cells occurs as the roots advance in age.

The rotenone content of the root depends on climatic and cultural factors, e.g. altitude, temperature, rainfall, size of cuttings and spacing in the field. The roots of the wild plants are poor in rotenone. Maximum yield of rotenone is obtained between the 18th and 25th months. Air-dry root yields at the latter time usually vary from about 880 Kg/ha when *D. elliptica* is used as an intercycle crop to about 1,100 Kg/ha as a solo crop (Georgi and Curtler, 1929). Harvesting is not difficult, since about 95 per cent of the root system lies within the top 45 cm of the soil surface.

Studies in Puerto Rica showed that 81 per cent of <u>Derris</u> roots were located in the top 44 cm of soil (Moore, 1940). The rotenone yield from wild plants cultivated under the most favourable conditions is about 5-6 per cent, whereas yields upto 13 per-cent are obtained from selected cultivars. Rotenone production from members of the genus <u>Derris</u> has centered largely on <u>D. elliptica</u> (Georgi and Teik, 1932; Higbee, 1948), but insecticidal properties of a lesser degree (Holman, 1940) are shown in plant parts of the following species : <u>D. amazonica</u> Killip, <u>D. chinensis</u>, <u>D. heptaphylla</u> Merr., <u>D. malaccensis</u> Prain, <u>D. philippinensis</u> Merr., <u>D. polyantha</u> Perk., <u>D. robusta</u> Benth., <u>D. thyrsiflora</u> Benth; and <u>D. trifoliata</u> Lour.
Ghose (1942); Rao and Seshadri, (1946), studied the rotenone and ether extractive in the roots of some <u>Derris</u> species found in India their analysis is depicted in Table No.1

	Species	Locality	Rotenone percentage	Ether extract air dry material %
i)	<u>Derris cuneifolia</u>	Golaghat (Assam)	0.1	1.2
ii)	<u>D. marginata</u>	Assam	0.15	1.6
iii)	<u>D. monticola</u>	Assam	0.1	2.0
iv)	<u>D. robusta</u>	Gouhati (Assam)	Nil	4.7
v)	<u>D. ferruginea</u>	Assam	0.1 - 2.4	1.0 - 4.5
	-do-	-do	4.3	7.3 *
vi)	<u>D. scandens</u>	Chanda (Madhya Pradesh)	Nil	6.7
vii)	<u>D. trifoliata</u>	Sundarbans (Bengal)	0.1	1.9

* Chloroform extract.

The pest control aspects of Derris have been summarised by Wealth of India (1952) authors in following Table :

Table 2 - Effect of Derris on some plant and animal pests

	Pest	Form of application	Observation
i)	Pieris rapae L., Plutella Maculipensis (Cabbage Worms)	Dust (0.5% or more rotenone)	Satisfactory control
ii)	Hypoderma spp. (Horse fly)	-do-	-do-
iii)	Heliothis obsoleta F. (Corn ear worm)	Dust (0.5% or more rotenone)	No effect
iv)	Thrips tabaci Lind (Onion thrips)	Spray	Promising
v)	Ixodes ricinus L. (Sheep tick)	in soap solution	destructive
vi)	Tetranychus telarius L. (Common red spider)	Spray (acetone extr. and sulphonated castor oil)	toxic
vii)	Camponotus spp. (Carpenter ants)	Powder (undiluted)	effective
viii)	Idiocerus spp. (Mango hopper)	aq. suspension (0.066%)	effective
ix)	Euproctis fraterna Moore	aq. suspension and alc. extr.	-do-
x)	Epilachna spp. (grubs)	aq. suspension and alc. extr.	-do-
xi)	Lecanium viride Gr.	aq. suspension and alc. extr.	-do-
xii)	Bruchus (Laria) Pisorum L. (Pea weevil)	dust (0.75 -1.0% rotenone)	Satisfactory
xiii)	Macrosiphum pisi Kalf. (Pea aphid)	dust	-do-

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	Pest	Form of application	Observation
xiv)	*Helopeltis* spp. (On cacao)	dust (0.75% rotenone)	effective
xv)	*Gnorimoschema operculella* Zell. (Potato moth)	dust (0.94% rotenone)	-do-
xvi)	Cockroaches	dust	-do-
xvii)	Wasps, hornets	Powder (undiluted)	-do-
xviii)	Cattle lice (all species)	dust (0.5% or more rotenone)	Controlled
xix)	Thrips (On cinchona seedlings)	dust (1% rotenone)	checked

Derris roots yield three other insecticidal compounds less effective than rotenone (Davidson, 1930) namely dequelin an isomer of rotenone and the isomers tephrosin and toxicarol (Clark, 1930a). Toxicity of *Derris* species to man and test animals is very low (Jones *et al*., 1968). The reports from Wealth of India (1952) suggest that the roots of *Derris scandens* contain scandenin ($C_{26}H_{26}O_6$; m.p. 233-234^o), nallanin ($C_{26}H_{26}O_5$; m.p. 201-202^o). The team of workers lead by Dr.LindaFellows at the Royal Botanic Gardens at Kew has reported occurrence of a polyhydroxyalkaloid 2,5-dihydroxy-methyl-3,4 dihydroxypyrrolidine from roots of *D. elliptica* (Brennan, 1988). These workers further serve as a mimic of fructose and because of anitmetabolic abilities pest control.

Shirgur (1977) reported that powders from the roots of *D. elliptica* were dependable substitutes for imported

Derris powder in India for clearing unwanted fishes from nursery ponds. Sinnappa, Thuan (1971) however pointed out that the use of *Derris* roots or its resin for fishing is wasteful as it kills the very young and small fish as well.

There are several other economic applications of *Derris* species. *D. elliptica* and *D. malaccensis*, *D. microphylla* (Miq.) vol., and *D. robusta* have served as green manures, shade trees and double cropping on rubber, Cacao, coffee, Kapok and tea plantation (Allen and Allen, 1981). Natives of eastern Malaysia consume the raw and cooked leaves of *D. heptaphylla* and also use them as culinary flavouring. The tree species *D. polyphylla* Koord. and Val. and *D. robusta*, yield wood useful for small buildings and turnery objects. The flexible stems of *D. malaccensis* and *D. trifoliata* make good cordage, *D. trifoliata* are used medicinally as stimulants, antipasmodics and counterirritants. The bark of this species, contains about 9.3% tannin (Allen and Allen, 1981). It is reported that the leaves of *D. scandens* and *D. trifoliata* are used as fodder by the local farmers (Maharashtra State Gazetter, 1961 . Agarwal, 1986). However the exact nutritional value of the leaves has not been worked out so far.