

**The School of Pharmaceutical and Biomedical Sciences
Pokhara University, P. O. Box 427, Lekhnath, Kaski, NEPAL**

**Monographs on *Datura*
*stramonium L***

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A Plant Monograph
on
Dhaturo
(*Datura stramonium* L.)



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Submitted to
The School of Pharmaceutical and Biomedical Sciences
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PREFACE

Datura was quite abundantly available in my village (Kuwakot-8, Syangja) since the days of my ancestors. Although its medicinal uses were not so clear and established at that time, my uncle had a belief that when given along with Gaja, it'll cure diarrhea in cattle. But he was very particular of its use in man and was constantly reminding me not to take it, for it can cause madness. I, on the other hand was very curious and often used to wonder how it looks and what'll actually happen if I take it. This curiosity was also fuelled by other rumours floating around in the village, of the cases of mass hysteria which happened when people took *Datura* with *Panchamrit* and *Haluwa* during *Shivaratri* and *Swasthani Puja*.

It was in 2052 B.S (I was in class 3 at that time) when an incident happened. One day I came earlier from school (around 2'0 clock), only to find nobody at home. The door was locked and I frantically searched for my mother and sister, but in vain. I was extremely hungry after long hours at school but there was nothing I could do rather than sit and wait for my mother to come. As I sat there, waiting, my eyes fell upon the plants of *Datura* in the orchard which bore some ripe fruits as well. Suddenly out of impulsiveness and hunger, I snatched some of the fruits (which contained thousands of seeds) and started chewing. I found the taste quite peculiar, sweet at first and later bitter at the time of swallowing. So there I was, a small boy who had just taken a handful of *Datura* despite all the cautionary advice from elders in the past. The result was something I would never forget. By the time the clock struck four, I had gone mad. I ran everywhere; roads that were bumpy seemed smooth to me. I even ran headlong to the wall since it seemed non-existent. Later of course, I had numerous scratches and cuts in my body as a reminder. Terrified of what had happened to me, my mum took me to the local healer (Jhankri). But I was not the one to be controlled; I sat on his shoulder with each of my leg dangling down his chest and pretended that I was riding a horse. Now, whenever that scene comes in front my eyes, I can't help but laugh over the angry face of the Jhankri and the carefree face of a young child who was determined at riding him despite his will. But at that time it wasn't funny; it was a sheer madness in my part and a forceful attempt on his, to control. The healer even tried to scare me by a burning log but I, rather than backing away, caught it and burned my hand. This incident left in them no doubt that there was nothing else they could do and so, they tied me up. On the third day, the effect finally left me. When I woke up, I had a body covered with bruises and cuts and a burnt hand. Needless to say, I fell sick for one whole week. Later, when everyone asked me, I replied truthfully that I had taken *Datura*.

So, after this incident, I was curious to know about the constituent in *Datura* that had caused me to go mad and the actual mechanism behind it. I tried searching for the answer while I was doing my intermediate in Science but wasn't quite able to gain the whole information. Luckily, when I got the chance to write a monograph on a plant, as a part of my syllabus here in P.U, I chose *Datura*. Now I know that the quantity of *Datura* that I had taken at that time was 'more than lethal dose.' I was lucky that I even lived to see this day. So, I would like to suggest everyone not to use any toxic substances without their complete information. For anyone who would like to gain complete information on *Datura*, I suggest them to please follow this monograph.

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MONOGRAPHS ON *DATURA STRAMONIUM* L.



Figure-1 *Datura stramonium* (URL-1)

1. INTRODUCTION

D. stramonium belongs to the Solanaceae family, which includes all the nightshades and agricultural plants such as eggplant, potatoes tomatoes, coffee and peppers. Solanaceae family belongs to about 90 genera and three sub-families. There are around 3000-4000 different species in all. They are believed to have evolved primarily in tropical areas, specifically in Latin America, allowing the family to develop extensive adaptive variations, even before human exploitation for crops. The particular characteristics of *D. stramonium* that are most notable are its poisonous nature and noxious smell, probably defenses against herbivores and attractive to some pollinators. The seed pods are also covered with sharp spines, to prevent animal ingestion of the seeds. A notable comparison can be made to another member of the nightshade family, peppers, which use “spicy” chemicals toward off predators.

The genus *Datura* shows the presence of huge genetic diversity. The classification of different species has relied heavily on genetic markers, which have lead to the discovery that this genus and family have immense variation due to mutation. This is probably linked to the genus' source in the tropics, where biodiversity is highest, even within species. (URL-2)

1.1 Origin:

It is doubtful to which country this plant originally belonged. Many European botanists refer it to North America, while there it is looked on as a denizen of the Old World. Nuttall considers it originated in South America or Asia, and it is probable that its native country is to be found in the East. Alphonse de Candolle in *Geographie Botanique* (1855), gives it as his opinion that *D. stramonium* is indigenous to the Old World, probably to the borders of the Caspian Sea or adjacent regions, but certainly not India; it grows wild abundantly in southern Russia from the borders of the Black Sea eastward to Siberia. Its seeds are very retentive of life, and being often in the earth put on shipboard for ballast, from one country to another, the plant is thus propagated in all regions, and it is now spread throughout the world, except in the colder or Arctic regions. Gypsies are also said to have had a share in spreading the plant by means of its seeds from western Asia into Europe. In the United States, it is now a familiar weed, found everywhere in the vicinity of cultivation, especially about barnyards, timber-yards, docks and waste places, frequenting dung-heaps, the roadsides and commons, and other places where a rank soil is created by the deposited refuse of towns and villages. Where the plant grows abundantly, its vicinity may be detected by the rank odour which it diffuses. Notwithstanding the abundance of the plant in North America, it is cultivated there in order to obtain a drug of uniform quality. The Bureau of Plant Industry, United States Department of Agriculture, has conducted experiments on a large scale: several hundred pounds of leaf were grown and cured by artificial heat in a tobacco barn, proving of excellent quality, being marketed at a price in advance of the highest quoted figures. In Great Britain, it is only occasionally found and can scarcely be considered naturalized here, though it is sometimes met with in the south of England, generally in rich, waste ground, chiefly near gardens or dwellings. It is sometimes grown in private gardens in England as an ornamental plant. It was cultivated in London towards the close of the

sixteenth century. The name Stramonium is of uncertain origin: some authorities claim that it is derived from the Greek name of the mad apple. *Stramonium* was the name of *D. metel* at Venice, in the middle of the sixteenth century, and the plant is figured under that title in the great Herbals of Tragus and Fuchsius. *D. stramonium* seems to have been a later introduction into Europe than *D. metel*, not becoming general till after the middle of the sixteenth century, but as it rapidly spread and became a common plant, the name of the latter was transferred to it. The generic name, *Datura*, is from the Hindoo *Dhatura*, derived from the Sanskrit, *Dhustura*, applied to the Indian species *fastuosa*, well known to the mediaeval Arabian physicians under the name of *Tatorea*. (URL-3)

1.2 History:

D. stramonium was grown in England by Gerard towards the end of sixteenth century from seeds obtained from Constantinople. The generic name, *Datura*, is derived from the name of the poison, *dhat*, which is prepared from Indian species and was used by the Thugs. (Evans, 2008)

De Candolle considered *D. Tatula* to be a native of Central America, then it was imported into Europe in the sixteenth century, and naturalized first in Italy and then in South-west Europe, where it is very common. It occurs in England more rarely than *D. stramonium*, under similar conditions and seems a more tender plant. It is sometimes cultivated here. The properties of both species are the same. In early times, the Thorn apple was considered an aid to the incantation of witches, and during the time of the witch and wizard mania in England, it was unlucky for anyone to grow it in his garden. (URL-3)
The generic name *Datura* is taken from the Arabic name for this plant, *Dhatura*. The Latin species name *stramonium* is the old generic name for this genus. The word is thought to be from *struma* which means swollen. (URL-4)

D. stramonium is native to either India or Central America. It was used as a mystical sacrament in both possible places of origin. The Native Americans have used this plant in sacred ceremonies. In some tribes *Datura* was involved in the ceremonies of manhood. The *sadhus* of Hinduism also used *Datura* as a spiritual tool, smoking it with cannabis in their traditional chillums. It was also widely used by the Magyar (Hungarian) spiritual leaders (the Taltos) since ancient times. In the United States it is called jimson weed, gypsum weed, angel trumpet, hells bells or more rarely Jamestown weed; it got this name from the town of Jamestown. (URL-5)

The effects of jimsonweed on the central nervous system have been exploited medicinally, recreationally and criminally. Long ago in India and Russia, ground-up seeds were mixed with water and used by thieves to daze victims before robbing them. The herb causes sedation, lack of will, and amnesia, so that victims were cooperative without being asleep. The Thugs, who belonged to an ancient Indian religious organization that worshiped Kali, the goddess of destruction, used the same mixture to rob and murder people. In Europe, thornapple seeds were well-known during the Renaissance as a poison.

In ancient times, the priests of Apollo at Delphi ingested small doses of jimsonweed leaves in order to inspire them when making prophecies.

In China, jimsonweed was prescribed for diseases of the feet, and for its sedative effects. Jimsonweed has also been used in China for flatulence, hyperacidity, and night sweats caused by tuberculosis. Asians also used the leaves as a painkiller, a decoction for skin problems, and a powder as an inhalant for respiratory problems. In India, seeds were prescribed to relieve epilepsy and heart disease. The dried leaves have been used in cigarettes as a treatment for asthma and bronchial complaints. *Datura* extracts have also been added to bronchial medications. In Europe, the dried leaves were as a treatment for asthma and cough (the anticholinergics in thorn apple would be expected to have a beneficial effect on asthma) the treatment was occasionally fatal.

Mexican Indians ingested a leaf decoction to relieve childbirth pains (later, scopolamine was used for this purpose).

In Europe, thorn apple seeds and extracts were used to treat mania, seizures, melancholy, rheumatism, and madness. Thorn apple was also prescribed as an anodyne (painkiller), an antispasmodic, and to treat seizures, delirium tremens, neuralgia, and rheumatism.

In Britain, an ointment made of thorn apple juice boiled in lard was used to treat inflammation and burns. The juice from the fruit has been used in an effort to prevent hair loss, while the juice from the flowers was used for earache. A leaf poultice of jimsonweed leaves has been used to treat cancer. (URL-6)

An interesting example of this is happened to British soldiers in 1676 sent to Jamestown, Virginia to quell Bacon's Rebellion. After including *D. stramonium* in a salad, the soldiers were reported to have gone mad for eleven or so days before the effects finally wore off. This incident is probably the source for *Datura's* common name jimsonweed, a shortened version of James Town weed.

From an anthropological perspective, the use of *D. stramonium* by Algonquin Indians of Virginia in their huskanawing ceremony provides an excellent example, of the role of hallucinogens during the liminal period in rites of passage. The concept of liminality was first discussed by Arnold Van Gennep in his *Rites of Passaga* (1908) and later elaborated on by Victor Turner. The liminal period is one part of rites of passage during which initiates are removed from social space and involved in reflection and learning about their particular society. Victor Turner has pointed to the importance of studying this phenomenon in order to understand processes of social change generationally within a culture. The use of *Datura* in this rite provides such insight.

Beverly in his *History of Virginia* (1705) described the rite of huskanawing. The rite was practiced by Algonquins every fourteen or sixteen years and involved taking the "choicest and briskest" young men of the society into the woods and ritually administering an intoxicating medicine (wysoccan), containing *Datura*, to them. The rite was necessary if the young men hoped to become great men or officers within their society. Kept in cages or enclosures for several months, the local medicine men carefully fed the boys only wysoccan, causing them to become "stark, raving mad" for a period of eighteen or twenty days so as to "perfectly lose the remembrance of all former things, even of their parents, their treasure, and their language." When sufficient dosages had

been administered, the amount was reduced gradually and the young men slowly returned to their senses. But before the potion completely wore off, the boys were brought back, into their village and carefully observed to see if any memories of their former life as boys were discovered. If one did show signs of remembering, the entire ritual had to be undergone again, this time greatly endangering the life of the initiate.

While the above descriptions make it appear like *Datura* is a fairly widely used, relatively harmless hallucinogenic plant, this is not at all the case. There is adequate reason for *Datura's* dark reputation and probably one of the more famous examples has to do with Abraham Lincoln's mother, Nancy Hanks. She apparently drank milk from a local cow that had grazed on the plant and consequently developed "milk sickness," a slow but fatal disease. Her death affected Lincoln tremendously and caused the President to remain abstinent from alcohol for the remainder of his life. The possibility of poisoning when taking *Datura* is fairly high and occurs often with symptoms similar to belladonna.

With its long history of human usage, one may ask how people learned to use *Datura* safely. One possible answer lies in the foraging habits of animals. Tribal peoples, living in a much closer relationship with nature, probably observed the effects *Datura* had on different species of animals and copied their eating strategies when consuming the hallucinogen themselves. Modern scientists have watched hawk moths feed on the flowers at night and become disoriented. Nonetheless, the moths continue to attempt to return to the plant for further feeding. Hummingbirds also favor *Datura* and after ingesting the narcotic perch, fluff their feathers, and then freeze stiff like corpses for several hours. Other research has also demonstrated that animals chose to eat hallucinogenic plants on an infrequent basis only, seeming to realize that tolerances can easily develop with regular usage.

Interestingly, some animals are unaffected by *Datura*. Beetles have developed biochemical defenses against the plants potent chemicals and ants appear to have done the same, often being observed carrying away the seeds. Bees are unaffected as well and various species of birds are known to eat the seeds, thereby acting as a dispersal mechanism for the plant. Using animals as a model to learn from, ancient hunters and gatherers probably began using *Datura* and many incorporated it into shamanistic rituals, a more controlled environment for ingestion of such a powerful and dangerous hallucinogen. (URL-7)

2. NOMENCLATURE

2.1 Scientific name:

Datura stramonium L.

2.2 Synonyms :

D. inermis Juss. ex Jacq.

D. chalybea W. D. J. Koch,

D. tatula (L.) Torr.

(URL-5)

2.3 Classification:

Table1:- Classification of *D. stramonium* (URL-8)

Kingdom	<u>Plantae</u> - Plants
Subkingdom	<u>Tracheobionta</u> – Vascular plants
Superdivision	<u>Spermatophyta</u> – Seed plants
Division	<u>Magnoliophyta</u> – Flowering plants
Class	<u>Magnoliopsida</u> - Dicotyledons
Subclass	<u>Asteridae</u>
Order	<u>Solanales</u>
Family	<u>Solanaceae</u> – Potato family
Genus	<i>Datura</i> L.
Species	<i>D. stramonium</i> L.

2.4 Local names of *D. stramonium* in different languages in Nepal:

Table 2:- Local names of *D. stramonium* in different languages in Nepal (Manandhar, 2002)

Nepali	Dhaturo, Seto dhaturo
Newari	Dhaturo
Tamang	Dhaturo
Tharu	Dhataur
Tibetan	Madak, Rda-rdu-ra

2.5 Sanskrit names:

धत्तूरधूर्तधुत्तूरा उन्मत्त कनकाह्वयः।
देवता कितवस्तुरी महामोही शिवप्रियः
मातुलो मदनक्षत्राय फले मातुल पुत्रकः

Dhatturdhurtadhustura Unmatta: Kanakahwaya:. Dewatakitawasturi Mahamohi Shivapriya:.

Matulo Madanashchasya phale Matulaputraka:.

(Shastri, 1997)

	Ghantika	Krishnadhatura	Shaiva
	Haravallabha	Madakara	Sama
	Kahalapushpa	Madana	Shatha
	Kalama	Madanaka	Shivapriya
Devika	Kali	Mahamohi	Shivashekara
Devata	Kanaka	Mahashatha	Shyama
Dhattira	Kanakaohaya	Matula	Tarala
Dhurta	Kantaphala	Matulaka	Turi
Dhurtakrit	Khala	Matta	Unmatta
Dhustura	Kharadushana	Mohana	Unmattaka
Dhuttura	Kharjhugna	Purimoha	
Ghantpushpa	Kitava	Savisha	

(Kritikar and Basu, 1999; Khare, 2007 and Joshi, 2000)

2.6 Local names in different languages outside Nepal:

Table 3:- Language names of *D. stramonium*

Country	Common names
Afghanistan	<i>Datura</i> , Kachola
Afrikaans	Olieblaar, Olieneut, Pietjie Laporte, Stjnkblaar
Adkim	Mmofra dhwene Pepediawu
Arabic	Janzelmathil
Ashanti	Pepediawu
Bengal	Sadadhutura
Brazil	Estramonio, Figueira do inferno
Canarese	Bilidattura, Biliyummatta, Dattura, Datturi, Dhattura, Dhustura, Duttura, Dutturi, Kariyummatta, Maddugunikke, Ummatta
Catalan	Estramoni, Figuera infernal borda, Rerba taupera
Chinese	Chan K' iue Tse, Tou K' iue Eul, Tsoui Sin Hoa
Danish	Pigaeble
Dutch	Doornappel
English	Apple of Peru, Devil's Apple, Devil's Trumpet, Dewtry, Jamestown, Weed, Jimson Weed, Mad Apple, Stink Weed, Thorn Apple, Stramonium
Fingo	UmVumbangwe

French	Chasse-taupe, Endormeuse, Endormie, Estramon, Herbe aux demons, Herbe des démoniaques, Herbe du diable, Herbe aux magiciens, Herbe des magiciens, Herbe aux sorciers, Herbe a la taupe, Hirare, Jusquiame du Pérou, Pomette, Pomme du diable, Pomme épineuse, Pomme du Pérou, Pomme de vallée, Put-put, Trompette du jugement
Ga	Blorfongrnetsho, Owura kofi
German	Asthmakraut, Botschen, Dollkraut, Dornapfel, Kroetenmelde, Nagwart, Stechapfel, Taternkraut, Tobkraut, Tollkraut, Zigeunerkraut
Greek	Strychnos manikos
Hungarian	Maszlág, Tsattanto
Italian	Imbutone blanco, Noce spinosa, Pomo spinoso, Stramonio
Japanese	Cyosen, Asagavo
Languedoc	Darboussiero
Loraiai	Shiriah azghi
Malayalam	Matulam, Ummam, Ummata
Llexic	Tiaplafi
Norwegian	Piggeple
Persian	Nanulah, Tatulah
Polish	Psinki
Portuguese	Estranionia, Figueira do inferno
Punjab	Datura, Tattur
Roumanian	Bolandarita, Ciurma fak
Russian	Durman, Durnjshnjik
South Africa	Apple of Peru, Devil's Apple, Devil's Trumpet, Dewtry, Fireweed, Jamestown Lily, Jamestown Weed, Jimson Weed, Mad Apple, Stinkweed, Stinkwort, Thornapple, White Stinkweed, White Stramonium
Spanish	Estramonio, Higuera loca, Trompetilla
Suto	Mphu fi, Lethsowe, Lethsowi
Swedish	Spikkluhha
Tamil	Emanamani, Simaiy iimattaj, Turutturam, Umattai. Vellumattai
Telugu	Duttu ramu, Tellavummetta, Ummetta
Tonga	Zabazaha
Tulu	Umbe

Turkis	Tatule
Urdu	Dhatura
Uriya	Dhutura, Sukladhutura
Xosa	UmHlavuthwa
Zulu	iLogi, iYoli

(Kritikar and Basu, 1935 and Joshi, 2000)

2.7 Medicinally used other species:

Table 4:- Medicinally used other species of *Datura*

Europe	<i>D. ferox</i> L., <i>D. metel</i> L., <i>D. stramonium</i> L.
China	<i>D. alba</i> Nees.
Cambodia	<i>D. metel</i> L.
Malasiya	<i>D. alba</i> Nees., <i>D. fastuosa</i> L., <i>D. metel</i> L.
Annam	The Philippine Islands, the Islands of Madagascar, <i>D. alba</i> Nees. <i>D. fastuosa</i> L.
La Reunion	<i>D. alba</i> Nees.
Central Australia	<i>D. hopwoodii</i> F. v. Muell.
Chile	<i>D. arborea</i> L.
Brazil	<i>D. stramonium</i> L.
Guiana	<i>D. ceratocaula</i> Jacq., <i>D. stramonium</i> L.
California	<i>D. meteoides</i> DC.
Guinea.	<i>D. metel</i> L.
Gold Coast	<i>D. metel</i> L., <i>D. stramonium</i> L.
South Africa	<i>D. stramonium</i> L., <i>D. tatula</i> L.

(Kritikar and Basu, 1999)

3. DISTRIBUTION/HABITAT

D. stramonium is naturalized to all four deserts of the American Southwest. Species of *Datura* can be found throughout the world, except in the colder or Arctic regions. The plant lives in sandy flats, plains, arroyos up to 2,500 feet above sea level, and amidst disturbed soils. Jimson weed is commonly seen among roadsides in the Southwest. (URL-9, URL- 12)

It is mainly found in The Himalaya from Kasmir to Sikkim up to 2700 m, hilly district of central and south India. (Khare, 2007)

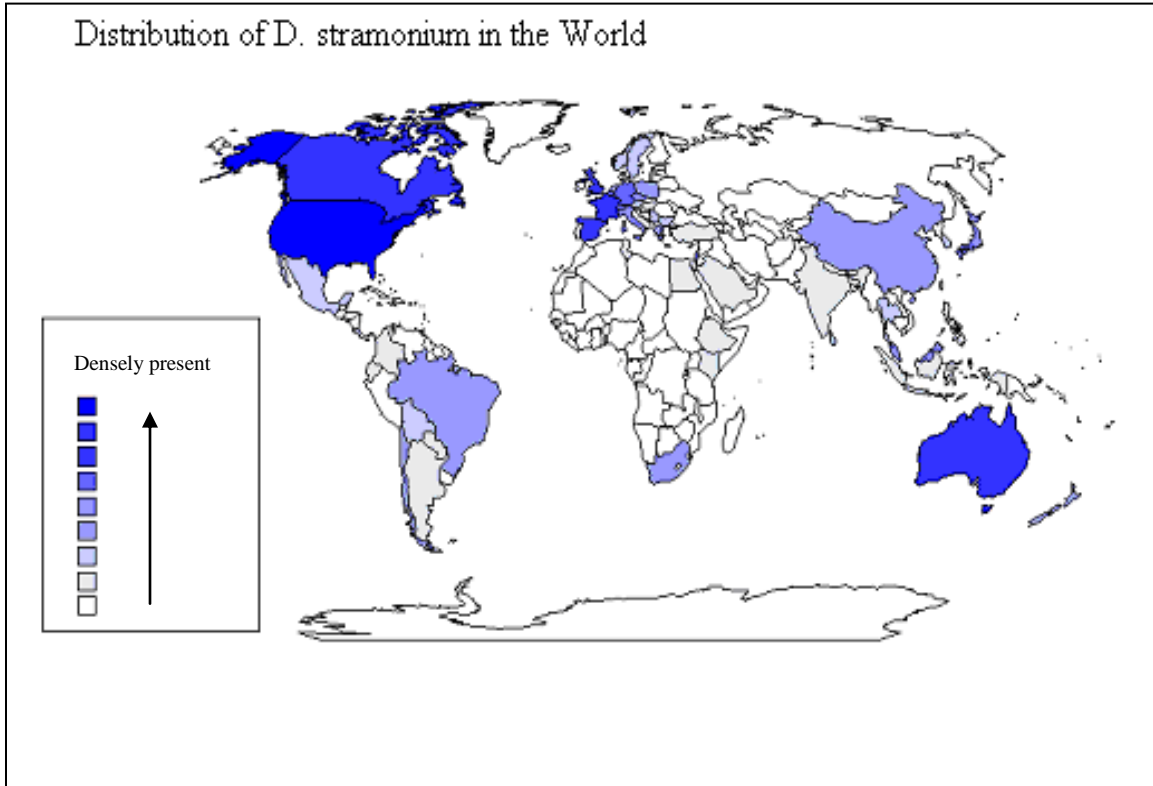


Figure-2 Distribution of *D. stramonium* in the World (URL-11)

Being of tropical origin, *D. stramonium* is a cosmopolitan weed of the warmer regions of North, Central and South America, Europe, Asia, and Africa. It grows nearly throughout the United States except for the Northwest and northern Great Plains, and as such is found throughout Pennsylvania. (URL-12)

It is essentially a temperate plant but is found growing in the vicinity of cultivation, on rank soil, where refuse is deposited, in all parts of world. (Joshi, 2000)

Datura is distributed throughout the world, particularly the warmer regions. *D. stramonium* is indigenous to India. Out of 15 species reported from different parts of the world, only 10 are known to occur in India. They are found commonly in wastelands, gardens and roadsides. They are distributed in rich localities under semi-arid and arid regions of Punjab, Haryana, Rajasthan, and Gujarat; the Central Plateau of Andhra Pradesh and Maharastra and the southern peninsular region of Tamil Nadu. *D. innoxia* is indigenous to Mexico and is distributed in Latin American countries. A wealth of genetic stock on genotypes and varieties are maintained in several research institutes in Germany, Bulgaria, USSR and Poland. Geographic distribution of *D. stramonium* is widely present across the United States. It has been reported in every state except Alaska and Wyoming.

Although most commonly found in agricultural areas, especially where grazing is present, the plant can thrive in a wide variety of climatic. In non-agricultural areas it can be located on the side of roads, where the soil has been disturbed. In California, the presence of Jimson weed has been expertly confirmed in every county along the coast except Del Norte and Mendocino, and its presence completely encircles the Bay Area. In Southern California the plant is present in every county along the coast and also inland in San Bernadino and Kern Counties. Jimson weed can be observed mostly in disturbed areas, like roadsides, agricultural fields and stream banks. While the plant can survive in numerous moisture regimes, it is most prevalent in a xeric regime (hot, dry summer, wet, cool winter). It requires an abundance of sunlight, and is rarely found in heavily wooded areas. It is not found in mountainous areas above the tree line. Although *D. stramonium* has an annual or short perennial life cycle, the seeds can remain viable for long periods of time, perhaps explaining its wide distribution throughout the United States. (URL-13, URL-14).

4. BOTANICAL DESCRIPTION

4.1 *Plants parts:*

4.1.1 Whole plants:

A glabrous (sometime farinose) annual herb, 50- 200 cm, in height (Joshi, 2000). This plant is a bushy, smooth, fetid, annual plant, and in rich soil. (URL-9, URL- 15)

The Thorn apple is a large and coarse herb, though an annual, branching somewhat freely, giving a bushy look to the plant. Its spreading branches covering an area almost as broad. On rich soil it may attain a height of even 6 feet. The plant is smooth, except for a slight downiness on the younger parts, which are covered with short, curved hairs, which fall off as growth proceeds. It exhales a rank, very heavy and somewhat nauseating narcotic odour. This foetid odour arises from the leaves, especially when they are bruised, but the flowers are sweet-scented, though producing stupor if their exhalations are breathed for any length of time. (URL-3)



Figure-3 *D. stramonium* plants (URL-16)

4.1.2 Root:

The root is rather large, of a whitish color, giving off many fibers, very long - thick. Root system consists of taproot that is shallow for the size of the plant; it branches frequently. (URL-3, URL-17)

4.1.3 Stem:

The stem is green or purple and largely hairless, although young stems often have conspicuous hairs, cylindrical, fistular. Stem is stout, erect and leafy, smooth, a pale yellowish green in color, branching repeatedly in a forked manner, and producing in the forks of the branches a leaf and a single, erect flower. (URL-3, URL-17)

4.1.4 Leaves:

The alternate leaves are up to 8 cm long and 6 cm across (excluding the petioles). They are ovate or ovate-cordate in outline, but pinnately lobed. These lobes are somewhat shallow and pointed at their tips; there are usually 2-3 of these lobes on each side of the leaf blade. The margin of each leaf may have a few secondary lobes or coarse dentate teeth; otherwise it is smooth or slightly undulate. The leaves may be slightly pubescent when young, but become hairless with age; the upper surface of each leaf is often dark green and dull. The foliage of Jimsonweed exudes a bitter rank odor. Leaves are cauline and ramal, exstipulate; alternate to opposite, petiolate, simple, dissected, acute, glabrous, unicosted, reticular venation. The leaves are large and angular, uneven at the base, with a wavy and coarsely-toothed margin, and have the strong, branching veins very plainly developed. The upper surface is dark and grayish-green, generally smooth, the under surface paler, and when dry, minutely wrinkled. (Keshari, 2005; URL-3, URL-17)



Figure-4 Stem of *D. stramonium*
(URL-16)



Figure-5 Leaves of *D. stramonium*
(URL-16)

4.1.5 Inflorescence:

Solitary, erect axillary (Keshari, 2005; URL-18)

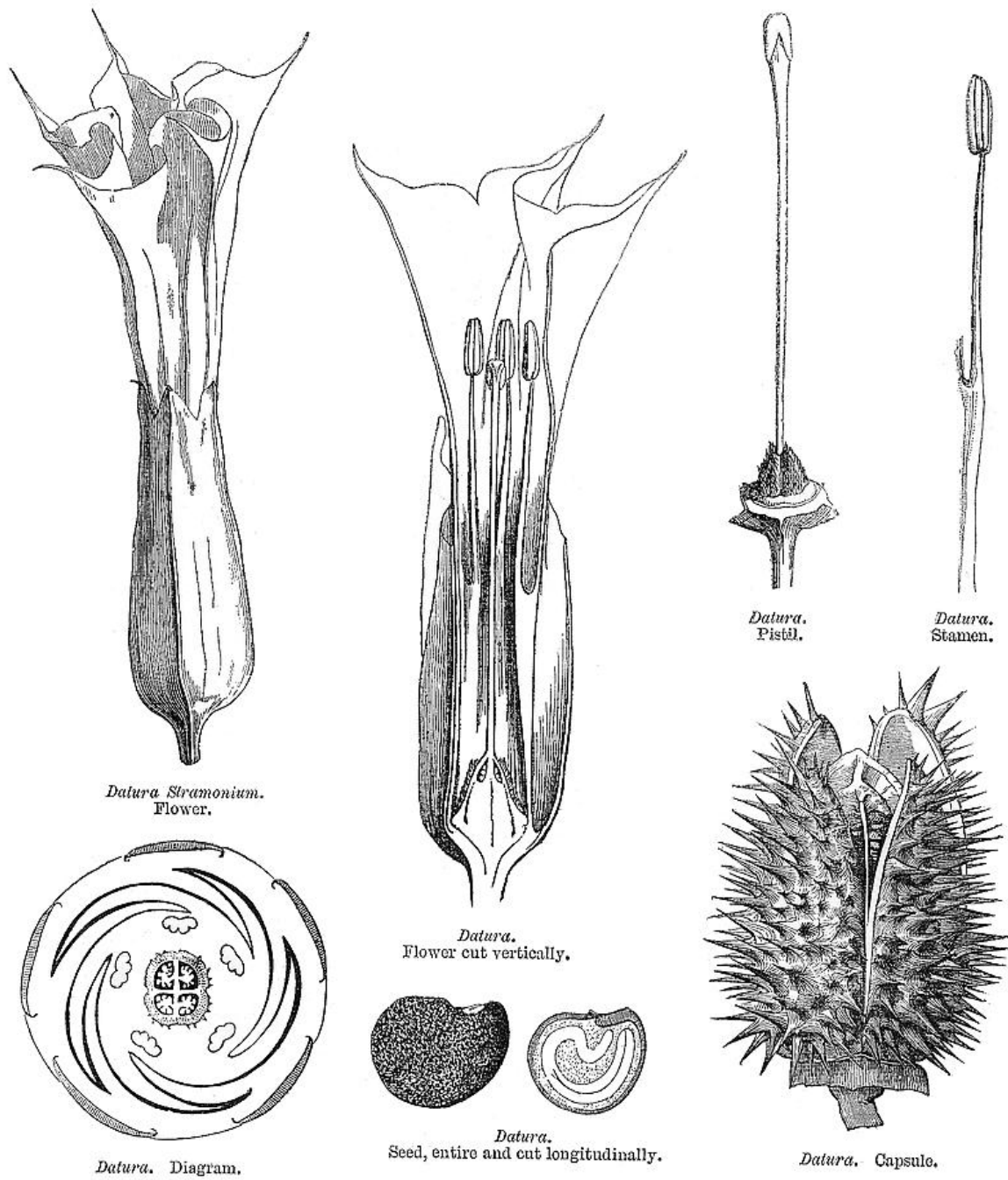


Figure-6 Inflorescence of *D. stramonium* (URL-19)

4.1.6 Flowers:

Ebracteate, ebracteolate, pedicellate, actinomorphic, bisexual, complete, regular, pentamerous, except fourth whorl, hypogynous. The plant flowers nearly all the summer. The flowers are large and handsome, about 3 inches in length, growing singly on short stems springing from the axils of the leaves or at the forking of the branches. The flowers are succeeded by large, egg shaped seed capsules of a green color, about the size of a large walnut and covered with numerous sharp spines, hence the name of the plant. When ripe, this seed-vessel opens at the top, throwing back four valve-like forms, leaving a long, central structure upon which are numerous rough, dark-brown seeds. The appearance of the plant when in flower and fruit is so peculiar that it cannot be mistaken for any other native herb. (Keshari, 2005; URL-3)

4.1.6.1 Calyx:

Sepals 5, gamosepalous, tubular, five toothed, sepaloid, hairy, persistent, valvate aestivation, inferior. The calyx is long, tubular and somewhat swollen below, and very sharply five-angled, surmounted by five sharp teeth. (Keshari, 2005; URL-3)



Figure-7 Flower of *D. stramonium* (URL-16)



Figure-8 Calyx of *D. stramonium* (URL-16)

4.1.6.2 Corolla:

Petals 5, gamopetalous, petals fused at the base, infundibuliform, surface hairy, white, twisted aestivation, inferior. The corolla, folded and only half-opened, is funnel-shaped, of a pure white, with six prominent ribs, which are extended into the same number of sharp pointed segments. The flowers open in the evening for the attraction of night-flying moths, and emit a powerful fragrance. The funnel form corolla of each flower is up to 5" long and 2" across when fully open; its outer rim has 5 shallow lobes. Each of these lobes forms an acute point in the middle. The corolla is white or pale violet throughout, except at the throat of the flower, where thick veins of dark violet occur (Keshari; 2005, URL-3, URL-16)

4.1.6.3 Androecium:

Stamens 5, polyandrous, alternipetalous, epipetalous, filament long and smooth, anthers ditheous, basifixed, introse, inferior. (Keshari, 2005)



Figure-9 Corolla of *D. stramonium*
(URL-16)



Figure-10 Stamen of *D. stramonium*
(URL-16)

4.1.6.4 Gynocium:

Carpels two (bicarpellary), syncarpous, ovary posterior obliquely placed to the right and anterior to the left, superior, bilocular with many ovules on swollen placentae, axile placentation, style long, stigma small, bilobed and capitate (Keshari, 2005)

4.1.7 Fruits:

Each flower is replaced by a hard fruit that is dry and spiny; it is about 1½" long, 1" across, and spheroid-ovoid in shape. Underneath each fruit is a truncated remnant of the calyx that curves sharply downward. These fruits are initially green, but become brown with maturity; they divide into 4 segments to release the seeds. (URL-17)



Figure-11 Fruit of *D. stramonium* (URL-16)



Figure-12 Developmental stage of *D. stramonium* Fruit (URL-20)

4.1.8 Seeds:

The large seeds are dull, irregular, and dark-colored; their surface may be pitted or slightly reticulated. Jimsonweed spreads by reseeding itself. (URL-8)



Figure-13 Seeds of *D. stramonium* (URL-21, URL-22)



Figure-14 Seeds inside the ripen fruit of *D. stramonium* (URL-23)



Figure–15 Fruit and Seed of *D. stramonium* (From Pharmacognosy laboratory of The School of Pharmaceutical and Biomedical Sciences, Pokhara University)

5. PHARMACOGNOSTICAL CHARACTERS AND PHARMACOPOEAL STANDARDS

5.1 Genetic characters:

Chromosome number-24, 48 (Joshi and Joshi, 2001)

The population of *D. stramonium* L. var. *tatula* T Orr and *D. wrightii* R Egel was heterogeneous in the numerical and structural composition of karyotypes. *Datura wrightii* contained, as well as aneuploid sets, a 35% karyotype with a diploid set of chromosomes ($2n = 24$); there were no chromosomes with satellites and there were 1-2 microchromosomes in 29.6% of the metaphases. *D. stramonium* L. var. *tatula* included biotypes with a chromosome number of 21-25; in 88.5% of the metaphases there were chromosomes with satellites and 60% of the metaphases contained 1-3 microchromosomes. According to the content of the main alkaloids *D. stramonium* L. var. *tatula* can be considered a predominantly hyoscyamine type, *D. wrightii* also containing scopolamine (URL-24).

5.2 Microscopic characters:

5.2.1 Histology of *D. stramonium* leaf:

According to British Pharmacopoeia leaf of *D. stramonium* consists of the dried leaves of flowering tops of *D. stramonium* and its varieties. The drug is required to contain not less than 0.25% of alkaloids calculated as hyoscyamine. (Evans; 2008)

The diagnostic characters of leaf microscopy are:

- a. The abundant fragments of the *leaf lamina in surface view*. The upper epidermis is composed of thin walled cells which are slightly sinuous in outline; the underlying palisade cells are irregular in size and rather loosely packed. The cells of the lower epidermis have markedly wavy walls and may occasionally show very slight thickening at the corners. Anisocytic stomata are present on both surfaces, being rather more numerous on the lower epidermis. In the regions over the veins, the epidermal cells are straight-walled and elongated.
- b. The *covering* and *glandular trichomes*, which are fairly abundant; they are usually found scattered but may occasionally be found attached to fragments of the epidermis. The covering trichomes are uniseriate, composed of three to four cells with thin, conspicuously warty walls; they are markedly conical, being wide at the base and tapering rapidly to the apex. The glandular trichomes have a short stalk and an ovoid to pyriform head composed of from four to seven thin walled cells.
- c. The *cluster crystals of calcium oxalate* which occur in a layer of cells in the spongy mesophylls immediately below the palisade. Fragments of this layer are frequently seen in surface view, attached to portions of the smaller veins; crystals are absent from the cells adjacent to the veins but most of the other cells of the layer contain one, or sometimes two, fairly large cluster crystals. Occasional prisms of calcium oxalate also occur and some of the fragments of the crystal layer contains somewhat abnormal crystals composed of a clusters embedded in a prism. All of these crystals are found scattered in the powdered as well as contained in the cells of the crystal layer
- d. The fragments of the *lamina in sectional view* showing the tubular epidermal cells with a smooth cuticle, the single layer of palisade cells with the underlying crystal layer and the irregular cells forming the remainder of the mesophyll
- e. The *parenchyma* of the mid rib composed of cells which are elongated longitudinally and have slightly thickened walls. Several of these cells contain cluster crystal similar to those found in the crystal layer of the lamina.
- f. The occasional fairly large *pollen grains* which are sub-spherical with these pores and an irregularly warty exine.

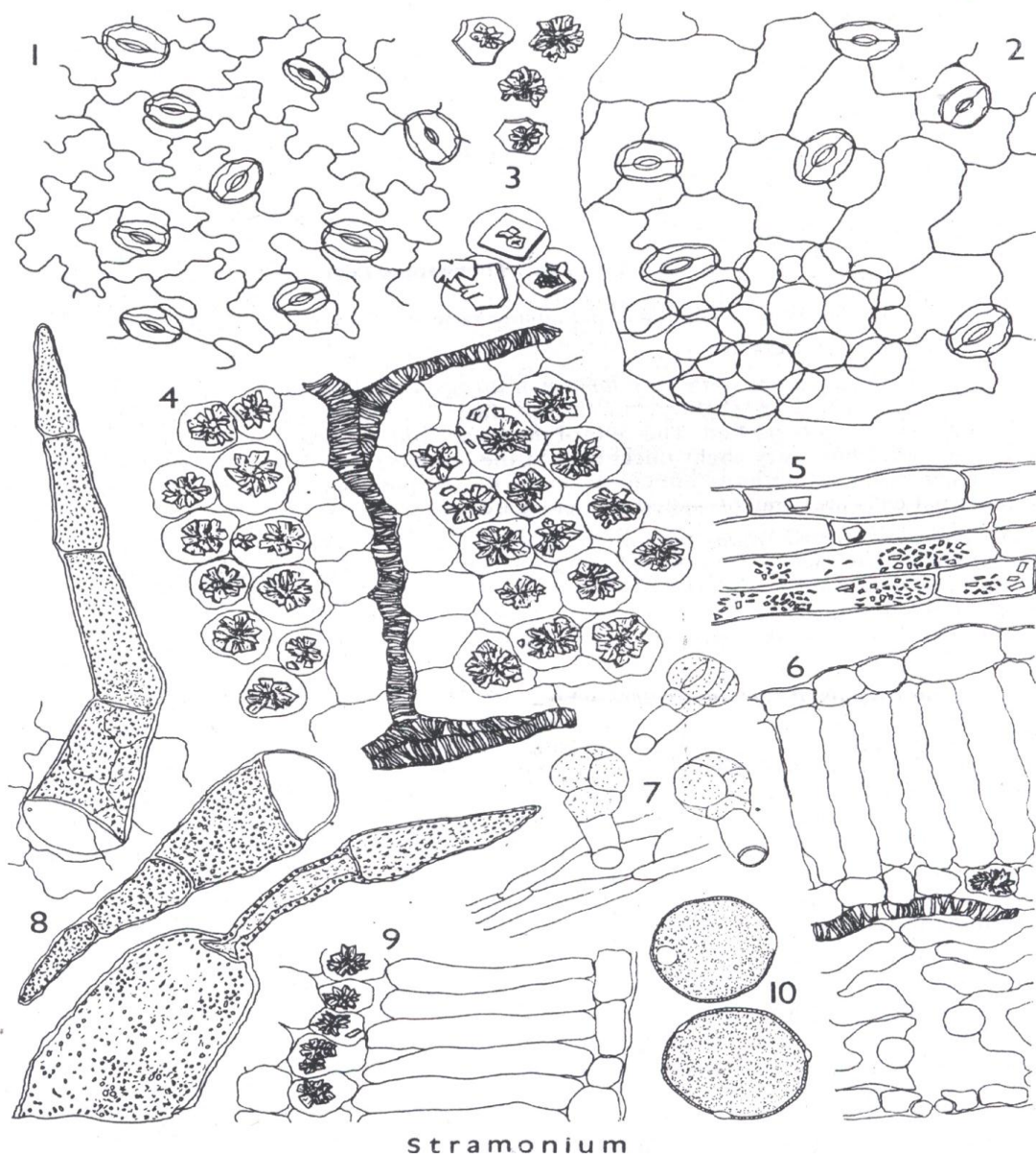


Figure-16 Histology of *D. stramonim* leaf

1. Lower epidermis in surface view showing anisocytic stomata.
2. Upper epidermis in surface view showing anisocytic stomata and part of the underlying palisade.
3. Calcium oxalate crystals, some contained in the cells of the crystal layer.
4. A fragment of the crystals layer in surface view showing part of a vein and the absence of crystals from the cells adjacent to the vein.
5. Parenchyma of the midrib in longitudinal view showing prisms and microsphenoidal crystals of calcium oxalate in some of the cells.

6. Part of the lamina in sectional view, including part of a small vein, showing the upper epidermis with underlying palisade, the spongy mesophyll and the lower epidermis with a stoma.
 7. Glandular trichomes, one attached to part of the epidermis over a vein.
 8. Covering trichomes.
 9. Part of the lamina in sectional view showing the upper epidermis, palisade and crystal layer.
 10. Pollen grains.
- (Jacson *et al.*, 2000)

5.2.2 Powder analysis:

Powdered Stramonium is bright green, or light olive brown to dusky yellowish green; epidermal cells of lamina with wavy radial walls; stomata elliptical, about 25 microns in length, usually with 3 neighboring cells, one smaller than the others; calcium oxalate in rosette aggregates, from 10 to 25 microns in diameter, or in prisms; non-glandular hairs of leaf few, 2- to 6-celled, attaining a length of about 500 microns, the basal cell being usually more than 50 microns in length and from 35 to 40 microns in diameter at the base, some of the cells more or less collapsed, the outer walls with numerous slight centrifugal projections; glandular hairs few, with 1- to 2-celled, usually curved stalks and 2- to 4-celled glandular heads; tracheae annular or spiral. Stem fragments with epidermal hairs up to 800 microns in length, occasional pericyclic fibers, annular or spiral tracheae or tracheae with simple or bordered pores associated with wood parenchyma or wood-fibers; midrib fragments with long, narrow, unequally thickened collenchymatous cells associated with parenchyma cells, some of the latter containing sphenoidal microcrystals and prisms U.S.(URL-25)

5.2.3 Microscopy of seed:

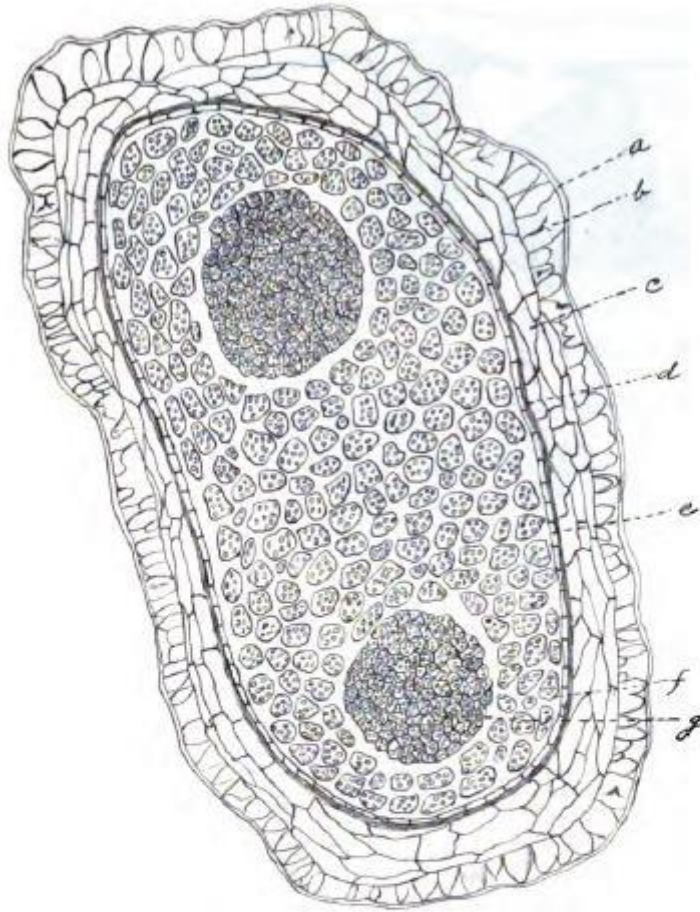


Fig. 1 Longitudinal section of the seed
a. Mucilaginous layer.
b. Epidermis cells.
c. Parenchyma cells
d. Absorbed parenchyma cells
e. Nucellus
f. Cells of endosperm
g. Embryo.

Figure-17 Microscopy of *D. stramonium* seed (URL-26)

5.3 Quality parameters:

Table 5:- Quality parameters of *D. stramonium*

Matter	Quantity
Mineral composition of seeds (mg/100g)	
Calcium	231
Chromium	0.22
Copper	1.64
Iron	130.05
Potassium	654
Magnesium	289
Manganese	13.40
Sodium	17.50
Zinc	5.95
Analysis from unrefined seeds (%)	
Moisture content	7.7
Fibre	17.8
Fat	18.1
Nitrogen	3.1
Carbohydrate	31.9
Starch	1.1
Sugar	2.1
Reducing Sugar	0.3
Glucose	0.16
Amino acids content in defatted seeds (g/16g)	
Arginine	6.54
Isoleucine	3.22
Leucine	5.31
Lysine	3.19
Methionine	1.38
Phenyl alanine	3.47
Threonine	3.14
Tryptophan	0.51
Valine	3.62

(Anonymous, 2003)

Foreign matter: Not more than 3% of stem having a diameter exceeding 5 mm

Total ash: Not more than 20%

Acid insoluble ash: Not more than 4%

Total alkaloids: Not less than 0.25% calculated as hyoscyamine

5.4 Gas chromatographic (GC) evaluation of atropine and scopolamine from *D. stramonium*

Column: Dual borosilicate 182.9 cm (6 ft) × 0.19 cm (0.075 inch) inside diameter
Stationary phase: Chromosorb G, acid washed, DMCS 80/100 with methyl silicone gum rubber liquid phase (conc. 2.5%)
Carrier gas (Helium): 9905+0.5 ml/min
Oven temperature: Temperature programming from 150-250 °C at the rate of 6 °C/min
Injection temperature: 315 °C

The method quantitates atropine and scopolamine as free bases. Atropine when subjected to GC produces two peaks, one corresponding to atropine and other to its degradation product apoatropine. Similarly scopolamine produces peaks of scopolamine and a product of lower molecular weight. For quantitative estimation the areas of respective degradation products should be combined with their base area that is

Area corresponding to atropine = atropine peak area + apoatropine peak area

Area corresponding to scopolamine = scopolamine peak area + area of its degradation product

Then standard curve is drawn for atropine and scopolamine by plotting amount injected Vs peak area

Linearity range for atropine: 0.5-210 µg

Linearity range for scopolamine: 0.5-187 µg

Solutions of alkaloidal bases were prepared in the chloroform.

Sample preparation : Moisten 10 g, previously reduced to a moderately coarse powder and accurately weighed, with a mixture of 8 ml of ammonium hydroxide, 10 ml of alcohol, and 20 ml of ether and extract the alkaloids by either of the methods given in the following two paragraphs. If necessary, reduce the volume of the extract to 100 ml by evaporation on a steam bath.

1. Place the moistened drug in a continuous-extraction thimble and allow maceration to proceed overnight, then extract with either for 3 hours or longer if necessary to effect complete extraction.
2. Place the moistened drug in a small percolator and allow maceration to proceed overnight. Percolate slowly with a mixture of 3 volumes of ether and 1 volume of chloroform. Continue the percolation until the residue from 3-4 ml of percolate last passed, when dissolved in dilute sulfuric acid (1 in 70) and treated with mercuric iodide, shows not more than a faint turbidity.

Transfer the extract quantitatively to a separator with the aid of ether. Extract with successive portions of approximately 0.5 N sulfuric acid, filtering each portion drawn off. Render the combined acid solutions distinctively alkaline with ammonia and completely extract the alkaloids at once with successive portions of chloroform. Evaporate the combined extract on a steam bath to dryness and then heat in a bath of boiling water for 15 minutes. Dissolve the residue in a small volume of chloroform, again evaporate to dryness and heat on a boiling water bath for 15 minutes. Dissolve the residue in a few ml

of chloroform and dilute with chloroform to a known volume so that the peak responses corresponding to atropine and scopolamine lie within the detector linearity range.

Procedure: inject known volume (0.2 μ l) of sample preparation into GC and record the Peak areas corresponding to atropine, scopolamine and their degradation products. Calculate their percentage using regression equation from standard curve

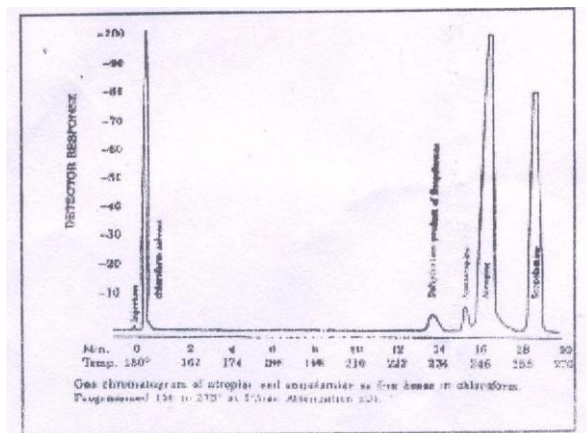


Figure-18 Gas chromatographic standard curve of Atropine and Scopolamine

(Farooq, 2005)

5.5 Organoleptic Properties:

The plant has strongly narcotic odor

5.5.1 Root

Whitish in colour

5.5.2 Stem

Pale yellowishgreen in colour

5.5.3 Leaf

Upper surface is dark and greyish-green, generally smooth, the under surface paler, exhales a rank, very heavy and somewhat nauseating narcotic odour. This foetid odour arises from the leaves, especially when they are bruised

5.5.4 Flower

Pure white, attractive, having powerful fragrance, sweet-scented, though producing stupor if their exhalations are breathed for any length of time. (URL-3)

6. COMMERCIAL PRODUCTION:

6.1 Cultivation:

6.1.1 Cultivation practices:

Datura grows well in a wide range of climate from tropical to temperate conditions.

The plant thrives best in areas of low rainfall where winter and monsoon rains are followed by long dry periods. Areas with annual rainfall below 1000 mm with mean temperature of 10-15°C in winter and 27 – 28 °C in May-June are ideal. The crop cannot stand frost, high rainfall or high temperature in the plains in May-June. It grows on majority of soils, however, alkaline or neutral clay, loam soil or those tending to saline-alkaline reaction rich in organic matter are ideal for vigorous growth. The clayey, acidic, water-logged or moisture deficient soils do not suit this crop.

The plant is propagated by seeds but it is characterized by poor and often erratic seed germination which can be improved either by leaching out the inhibitor from the seeds or by alternate freezing and thawing of seeds. The seeds can be broadcast - sown or seedlings can be raised in nursery and then transplanted. Seed rate is 7-8 kg/ha for broadcasting and 2-3 kg/ha. for transplanting. The field is ploughed and disced adequately to produce fine seed bed. In the case of direct seeding, seeds are drilled in rows taken 45-60 cm apart. The plants are thinned to keep a spacing of 30-45 cm at the time of first weeding. In the case of transplanting 4-6 weeks old seedlings are planted at 45-60 x 30-45 cm spacing.

The field should be irrigated immediately after sowing or planting if soil moisture is inadequate. Thereafter 3-4 irrigations may be given if sufficient rainfall is not received.

Application of organic manure at 10-15 t/ha and fertilizers at 60:40:40 kg N, P₂O₅ and K₂O/ha is recommended for the crop for better growth and yield may be applied in 3-4 equal split doses at planting and after each weeding which is required 2-3 times during the growing season. Application of micronutrients is reported to improve the alkaloid contents.

No major insect pest is known to attack this crop. However, leaf spot wilt and mosaic diseases cause damage to this crop. Leaf spot is caused by *Alternaria tenuissima* (Nees) Wiltshire and characterised by brown round to oval spots, becoming necrotic at later stage which leads to withering and dropping of leaves. Wilt is caused by *Sclerotium rolfsii* Sacc; it starts with dropping of leaves and finally wilting of the entire plant. Root and foot wilt, caused by *Corticium solani*, appears as damping off of seedlings and mature plants. *Datura* distortion mosaic is characterized by yellowing of the veins followed by inward rolling and distortion of leaves with a reduction in plant size. For

reducing the impact of these diseases, field sanitation, use of resistant varieties, crop rotation for 3-4 years and fungicide application should be resorted to. For the purpose of leaf and top, harvesting is done as soon as flowering starts. Entire top containing leaves and twigs is cut, dried in shade and stored in gunny bags. For seed and fruit, fully grown fruits, still green are picked 2-3 times before final harvest when the entire plant is cut from the base and dried in the open. The dried fruits are then thrashed with a stick to separate the seeds. The seed yield is 1-1.5 t/ha.

The preference is full or partial sun, moist to mesic conditions, and a rich fertile soil with high nitrogen content. This type of soil is necessary to supply the nutrients that are required by the prodigious growth of this annual plant. The foliage is often pitted by tiny holes that are made by flea beetles (the same species that attack eggplant). The seeds can remain viable in the ground for several years.

Thorn apple is easily cultivated, growing well in an open, sunny situation. It will flourish in most moderately good soils, but will do best in a rich calcareous soil, or in a good sandy loam, with leaf mould added. Seeds are sown in the open in May, in drills 3 feet apart, barely covered. Sow thinly, as the plants attain a good size and grow freely from seed. Thin out the young plants to a distance of 12 to 15 inches between each plant in the drill. From 10 to 15 lb. of seed to the acre should be allowed. The soil should be kept free from weeds in the early stages, but the plants are so umbrageous and strong that they need little care later. If the summer is hot and dry, give a mulching of rotted cow-manure. The plants may also be raised from seeds, sown in a hot-bed in February or March, or in April in boxes in a cool greenhouse, the seedlings, when large enough, being transferred to small pots, in which they are grown with as much light and air as possible till June, when they are planted in the open. Thorn apple transplants readily. If grown for leaf crop, the capsules should be picked off as soon as formed, as in a wind the spines tear the leaves. Some seed, for propagation purposes, should always be collected from plants kept especially for the purpose. Though cultivated in this country, on some of the herb farms, such as Long Melford and Brentford, Thorn apple was not much grown on a commercial scale before the War, considerable quantities of the dried leaves having always been imported from Germany and Hungary.

D. stramonium is propagated by seeds sown *in situ* in spring (16°C / 61°F) or earlier under glass and set out after danger of frost has passed. The foliage is extremely susceptible to viruses affecting other Solanaceous plants and may act as a host. *Datura* seems to be awkward genera in that it will often grow like a weed and at other times seems to resist every attempt at germination. *Datura* seem to occur naturally on fertile wasteland, rubbish tips, dry river banks and roadsides - they almost always start growing where the ground has been recently disturbed (giving the seeds sheltered nooks where plant material can gather and rot, and where the humidity is maintained by being sheltered from direct sunlight and wind). If similar conditions are reproduced *Daturas* can be very successful sown in-situ outdoors. Aerial parts of perennial species die back during the winter (if frosted) and will grow back from the roots in spring.



Figure-19 Growing phase of *D. stramonium* (URL-27)

There seem to be 3 things that encourage good germination (*Datura stramonium*): (URL-1, URL-8, URL-10, and URL-28)

6.1.1.1 Temperature:

One experiment was conducted to evaluate the effect of temperature on the germination of *D. stramonium* seeds. The procedure and results are as follows

6.1.1.1.1 Untreated Seeds versus Temperature:

Petri dishes were sterilized at 120 °C for 4 hours in an oven. Filter papers were placed in them to prepare seed beds. Filter papers were moistened with distilled water avoiding excess of water at any time. 10 seeds were kept on the filter paper; replicated six times for each test. Petri dishes were always sealed with "polythene bags". They were checked after every 24 hours and rewatered when necessary with the help of dropper. Four ranges of temperature i.e. 25 °C, 30 °C, room temperature (32 °C) and 35 °C were used for every test. Emergence of radical was taken as the index of germination. The experiment was tried for ten days to find the temperature and time interval for the best germination.

6.1.1.1.2 Mechanically Scraped Seeds versus Temperature:

Due to low germination percentage, obtained from previous procedures, the seeds of *D. stramonium* L. were mechanically scarified between two sand papers till the testa is ruptured from one point or is totally removed without injuring the embryo. After mechanical scarification the seeds were transferred to the Petri dishes and kept at 25 °C, 30 °C, and 35 °C. The experiment was tried for 10 days to find the temperature and time interval for the best germination

Table 6:- Result showing the percentage of germination of a) untreated and b) mechanically scraped seeds of *D. stramonium* L. at different temperatures in the laboratory.

No. of Days	% age germination (a)			
	25 °C	30 °C	32 °C	35 °C
2	-	-	-	-
4	-	28.33	8.33	-
6	-	36.66	10.00	-
8	-	36.66	11.66	-
10	-	36.66	18.33	3.33

No. of Days	% age germination (b)			
	25 °C	30 °C	32 °C	35 °C
2	5.00	11.66	3.33	13.33
4	13.33	18.33	8.33	16.66
6	16.66	30.00	18.33	16.66
8	18.33	35.00	21.66	21.66
10	18.33	40.00	33.33	23.33

- no germination

In untreated seeds of *D. stramonium* L., maximum germination percentage was observed at 30 °C, suddenly decreased at 32 °C and absolutely negative results were obtained at 25 °C and 35 °C. With the removal of testa greatest percentage of germination was observed at 30 °C after 10 days. It is concluded that optimum temperature for the germination of *D. stramonium* L. seeds is 30 °C. With the removal of testa the percentage of germination increased. So it is concluded that hard testa of *D. stramonium* L. seed slows down germination. The seed coat is nearly impervious to the diffusion of gasses, and embryo may be maintained in the dormant condition due to lack of oxygen. For metabolism oxygen is necessary. The seed covering may prevent the absorption of water and thus limits germination. (Marwat *et al.*, 2005)

6.1.1.2 Light:

Sow with just a very thin sprinkle of sand or vermiculite on top of the seeds - experiments have produced results of 15% to 25% germination in the dark and 27% to 100% germination with some exposure to light (not direct sunlight as this will cook the seeds or burn the sprouts of those that germinate - the small plants must be gently introduced to full sunlight).

6.1.1.3 Humidity:

Covering the seed tray with a sheet of glass, or cling Film will maintain the humidity. Propagating trays with clear plastic covers are also useful, they usually have air vents so that damping off can be prevented once germination commences.

Gibberellins (Gibberellic Acid-3 (GA-3)) have been found to stimulate germination amongst *Daturas*, but many growers prefer not to use them. Gibberellins are naturally produced by fungal action when leaves and other plant material decay - some compost or leaf mold blended with the seed mix may *Daturas* are subject to statutory control as weeds in some countries. (URL-10)

6.1.1.4 Requirements for cultivation practices

6.1.1.4.1 Climate

Datura seeds are sown in October to, January or spring season.

6.1.1.4.2 Soil

It can be grown in any kind of soil but for good production, medium loam soils are highly suitable.

6.1.1.4.3 Manures and fertilizer management

For its cultivation, land should be ploughed 2-3 times. About 10 tons of cow dung manure or good decayed compost per hectare should be applied and along with this 25:50:25 kg of nitrogen, phosphorus and potash should be mixed in the soil.

6.1.1.4.4 Sowing

Datura is sown by seeds. About 7-8 kg of seed is needed per hectare. Sometimes nursery is raised first and when plants attain 8-12 cm height, they are transplanted in well prepared field.

For better germination, soak the seeds in water over night or wash seeds with water and place in rows 1 metre apart and cover with soil. Within 10 days germination starts and complete germination is over in one month. Seedlings when attain a height of 10-12 cm or when plants have four leaves they should be transplanted.

6.1.1.4.5 Weeding and interculture

When *Datura* plants are 10-12 cm tall all the weeds should be removed. At this stage plant to plant distance in the row should be 70-90 cm and weak plants should be removed from the row.

6.1.1.4.6 Irrigation

If there is no rain after sowing then one irrigation should be given within a week. Afterwards irrigation may be given at an interval of 10-15 days.

6.1.1.4.7 Improved varieties

1. RRL Neel Lohit (Purple):

Its whole plant along with the leaves is purple. It yields 240-290 quintal per hectare of green stubble and leaves and 18-24 quintal of seed. The amount of alkaloid in the seed is 0.24-0.36% and in leaves it is 0.12 to 0.19%.

2. RRL Green:

The stem is green and its leaves are light green. This is a late season crop. It yields 210 quintal of leaves per hectare containing 0.24-0.28% alkaloid. It also yields 15-20 quintal of seed having 0.09-0.128% alkaloid.

6.1.1.4.8 Yield

The main medicinal products of *Datura* are leaves and seeds. On an average about 200-1700 kg/ha of dry seeds are obtained. The seeds contain 0.2-0.35% alkaloid.

(Govil *et al.*, 2002)

6.2 Ecology:

The study evaluated how natural selection acts upon two proposed alternatives of defense (growth and resistance) against natural enemies in a common garden experiment using genetic material (full-sibs) from three populations of the annual plant *Datura stramonium*. Genetic and phenotypic correlations were used to search for a negative association between both alternatives of defense. Finally, the presence/absence of natural enemies was manipulated to evaluate the selective value of growth as a response against herbivory. Results indicated the presence of genetic variation for growth and resistance (1--relative damage), whereas only population differentiation for resistance was detected. No correlation between growth and resistance was detected either at the phenotypic or the genetic level. Selection analysis revealed the presence of equal fitness benefits of growth and resistance among populations. The presence/absence of natural herbivores revealed

that herbivory did not alter the pattern of selection on growth. The results indicate that both strategies of defence can evolve simultaneously within populations of *D. stramonium*. (Valverde *et al.*, 2003)

In the annual weed *D. stramonium* the existence of genetic variation for tolerance and fitness costs of tolerance is explored. To determine which fitness-related trait was responsible for possible differences in tolerance, growth rate, total flower and fruit production, and the number of seeds per fruit were recorded. Inbred line replicates of *D. stramonium* from a population of Mexico City were exposed to four defoliation levels (0%, 10%, 30%, and 70%). Results from a greenhouse experiment using controlled genetic material (inbred lines) indicated that significant genetic variation for tolerance was detected across defoliation environments. Defoliation reduced plant fitness from 15% to 25% in the highest levels of defoliation. Differences on tolerance among inbred lines were accounted by a differential reduction in the proportion of matured fruits across defoliation levels (up to 20%). Within defoliation levels, significant genetic variation in plant fitness suggests that tolerance could be selected. The correlation between fitness values of inbred lines in two environments (with and without damage) was positive ($r_g = 0.77$), but not significant, suggesting absence of fitness costs for tolerance. The finding of genetic variation on tolerance might be either due to differences among inbred lines in their capability to overcome foliar damage through compensation or due to costs incurred by inducing secondary metabolites. A result also indicate the potential for norms of reaction to be selected under a gradient of herbivory pressure and highlights the importance of dissecting induced from compensatory responses when searching for potential causes of genetic variation on tolerance. (Fornoni *et al.*, 2000)

6.3 Soil and manure:

It can be grown from seeds sown in spring in drills. The plant is sensitive to frost and sheltered situations are, therefore, preferred for cultivation. Nitrogen manuring, which favours the growth of plants, also favours alkaloid formation. tetraploids produced by colchicines treatment contain more alkaloids (sometimes double the amount) than diploids. (Anonymous, 2003)

Germination studies under various soil conditions was done in an experiment as follows

6.3.1 Pot experiment

(a) Preparation of soil

As for the project, five types of soil were suggested and were prepared as follows:-

1. Clayey Soil: Pure clayey soil was brought from a typical area and made uniform by hands. Equal volume was put in 5 pots of large size.

2. Sandy Soil: Pure sand, which was brought from a typical area, was used in equal volumes in 5 pots of the same size.

3. Loamy Soil: Loamy soil was prepared by mixing clay and sand mentioned above in (1) and (2) in equal proportion by volume. Equal volume was put in 5 pots of the same size as mentioned above.

4. Leaf Mold soil: Leaves buried in the soil with other organic matters of the Botany Department, Peshawar University, were used as a soil which was given name Leaf Mold Soil. Equal volume of this soil was put in 5 pots of the same size as mentioned above.

5. Control Soil: The garden soil of Botany Department, University of Peshawar, was used as control soil which is clayey loam. Equal volume was put in 5 pots of the same size.

(b) Sowing of Seeds:

Before sowing, the viability of the seeds was determined by floating test. The healthy seeds were selected and sown at the rate of 10 seeds per pot. They were slightly watered to moisten the surface layer of the soil and were checked after every 24 hours. After 17 days seeds germination started. The first seeds germinated, were, in leaf mold soil. Next day in sandy soil germination started and then in loamy, clayey and control soil (clayey loam) seeds were sprouted. The germination was checked for 33 days, after which germination stopped.

6.3.2 Field Experiment

A field experiment was set up simultaneously with pot experiment to study the germination under different five types of soil in the field condition. Five culture beds of 0.84 x 1.3 m were designed for this purpose. All the beds were in two rows. The distance between every two beds was 0.61 m.

(a) Preparation of Soils:

Five different types of soil were prepared as mentioned already in (A). Each type of soil was put in one bed up to the depth of 18 cm. The surfaces of soils were leveled by kurpa.

(b) Sowing of Seeds:

Before sowing, the viability of seeds was determined by floating test as mentioned earlier. The viable seeds were sown at the rate of 50 seeds per bed. Sowing was done in rows. They were slightly watered daily to moisten the surface layer of the soil and checked after every 24 hours. After 13 days germination started and the checking was done for 25 days, because after this period germination stopped.

Table 7:- The percentage of germination of *Datura stramonium* L. seeds in the a) Pot Experiment and b) Field Experiment in different soil conditions. 25 pots (5 pots for each type of soil) were used, each with 10 seeds, (5 beds were employed, each with 50 seeds

a)

Type of soil	Total no.of seeds sown	Total No. of germinated seeds	% germination
Clayey soil	50	20	40
Loamy soil	50	21	42
Sandy soil	50	28	56
Control soil	50	8	16
Leaf Mold (Soil)	50	30	60

b)

Type of soil	Total no.of seeds sown	Total No. of germinated seeds	% germination
Clayey soil	50	30	60
Loamy soil	50	20	40
Sandy soil	50	32	64
Control soil	50	24	48
Leaf Mold (Soil)	50	36	72

During the study of the germination of *D. stramonium* L. seeds in different types of soil, maximum germination percentage was found in leaf mold soil, in both pot and field experiments. This is due to its properties which provide most favorable environment for germination.

Leaf mold soil is very porous having large spaces for storing of oxygen. It has organic matters which affect water contents by retaining it in large amount on the extensive surfaces of its colloidal constituents and holding it like a sponge in its less decayed portions.

The second highest percentage of germination of the seeds of *D. stramonium* L. is in sandy soil.

Sands are the coarser particles of the soil. They are loosely arranged and have large spaces as compared to clayey, loamy, and clayey loam soils. They have no compactness, so in sandy soil aeration is exceptionally favorable, temperature is relatively high and has lower moisture holding capacity.

The third highest germination percentage is in loamy soil. It has both the properties of clayey and sandy soils. It is relatively less porous as compared to sandy soil.

The germination percentage of the seeds of *D. stramonium* L. is less in clayey and control (clayey loam) soils as compared to other three types of soils as mentioned above. According to Weaver and Clements (1938), the chief physical properties of clay are a high water holding capacity, high plasticity or stickiness. Clayey soil has fewer amounts of oxygen and temperature due to poor porosity. (Marwat *et al.*, 2005)

6.4 Soil pH requirements:

6.1 to 6.5 (mildly acidic)

6.6 to 7.5 (neutral)

7.6 to 7.8 (mildly alkaline)

(URL-29)

6.5 Training and Pruning:

D. stramonium abuse causes a potentially lethal anticholinergic intoxication. Today, with the internet widely available, youth are potentially exposed to partial and quite often dangerous information that systematically disregards the danger of *Datura* use. Without educational efforts regarding the dark side of *Datura* use, there is rise in poisoning by this dangerous substance. So general management of the intoxication of *D. stramonium* should be educated. (Berger *et al.*, 2003)

2 cases of teenagers who were poisoned with Jimson weed (*D. stramonium*) and presented to the emergency department with a severe acute anticholinergic toxidrome after ingestion of several hundred seeds were reported. The patients presented with visual hallucinations, disorientation, incomprehensible and nonsensical speech, and dilated sluggish pupils. Both patients required restraints for combativeness until adequate sedation with lorazepam and haloperidol was achieved. Jimson weed is found in southern Canada and the United States and can cause acute anticholinergic poisoning and death in humans and animals. The treatment of choice for anticholinergic poisoning is mainly supportive care and gastrointestinal decontamination with activated charcoal. Jimson weed intoxication should be considered in cases of patients presenting with unexplained peripheral and central anticholinergic symptoms including delirium, agitation and seizures, especially among younger patients and partygoers. It is important that health care professionals recognize that Jimson weed is a toxic, indigenous, "wild" growing plant, subject to misuse and potentially serious intoxication requiring hospitalization. (Spina *et al.*, 2007)

6.7 Nutrition:

The sucrose requirements of *Datura stramonium* embryos in vitro have been studied over an incubation period of 8 days. Different stages of development require different minimal sucrose concentrations for growth: pre-heart stages, 8-12%, late heart stage, 4%, nearly mature embryos grow even without sucrose. The optimal concentration for hypocotyls is $\pm 8\%$ in preheart stage and decreases to 1.0-0.5% in torpedo stage. Cotyledons and hypocotyls have the same growth rate up to 5-8 mm. Thereafter hypocotyls alone continue growth. Roots develop when hypocotyls are 2.5-4 mm. long. Their optimal sucrose concentration is $\pm 2\%$. Higher concentrations than 4% decrease root formation. Different embryo stages require different osmotic values of the medium. The optimal osmotic value decreases as the embryo stage advances. If the osmotic value is kept constant, all embryo stages respond in the same way to changes in the sucrose concentration. (URL-30)

6.8 Pests and Diseases:

The flowers are pollinated by Sphinx moths. Various species of beetles are attracted by the flowers, especially at night, where they steal nectar and chomp on the pollen. The foliage and its juices are consumed by flea beetles, aphids, psyllids, and other small insects; their presence attracts ladybird beetles and other predatory insects. The foliage and seeds contain an impressive assortment of toxic alkaloids that can be fatal to mammalian herbivores and humans. (URL-16)

6.8.1 Diseases:

6.8.1.1 Leaf spot:

Causal organism: *Alternaria alternata*, *A. rrasa*

Symptoms: The disease appears as water soaked circular spots on leaves. In later stages the spots coalesce, become dull yellow and then turn to light brown due to the death of the infected tissue. A single spot on a leaf cause curling of entire leaf in advanced stages of infection. The wilting of the entire branch of the plant occurs when 2-3 leaves of a single branch are affected. Leaves of affected branch curl and this is followed by death and defoliation. Such plants do not form normal fruit and seeds. Older leaves are more susceptible to infection as compared to younger ones.

Control: Spraying 2-3 times copper oxychloride (3 g/b or mancozeb) 2.5 g/L any other thiocarbamates controls this disease.

6.8.1.2 Carpospora leaf spot

Causal organism: *Carpospora jamaicensis*

Symptoms: The disease was characterized by sub circular to irregular, scattered but often coalescing leaf spots. 1-11 mm diameter. In the early stage of the disease the spots are huffy brown in color but later they become alive, brown on account of numerous fructifications.

Control: Three to four spraying with dithane M-45 (2.5 g/U at 10 days interval or bavistin (1.5 g/l or duter or cercobin (2.5 g/L) at 15 days interval has been found effective against spread of leaf spots in the field.

6.8.1.3. Charcoal rot

Causal organism: *Macrophomina phaseoli*

Symptoms: The disease appears as black sunken cankers just below the cotyledonary node at the time of emergence. The lesions later extended up to the stem as far as leaf petioles and sometimes reach up to the growing point. Leaf yellowing and stunting are observed with the advancement of the disease. Gradual withering of leaves starting from the lower ones is noted. The withered leaves remain attached even after death of the plant. The fruit remain unfilled and seeds immature. Black pin head like pycnidia and sclerotia are found all over the bark inside the pith, below the epidermis and within the xylem vessels.

Control: 1. Furrow application of PCNP (Brassical) or thiram at the rate 8 kg/ha at planting time gives good relief. (Govil, 2002)

6.8.2 Pests

Various viruses those are susceptible to *D. stramonium* are as follows:

Abelia latent tymovirus	Chickpea chlorotic dwarf monogeminivirus
Abutilon mosaic bigeminivirus	Chicory yellow mottle nepovirus
Alstroemeria ilarvirus	Chino del tomat, bigeminivirus
Arabis mosaic nepovirus	Commelina X potexvirus
Arracacha A nepovirus	Cowpea mosaic comovirus
Arracacha B nepovirus	
Artichoke latent potyvirus	Cowpea severe mosaic comovirus
Asparagus 3 potexvirus	Croton yellow vein mosaic bigeminivirus
Bean distortion dwarf bigeminivirus	Cucumber mosaic cucumovirus
Belladonna mottle tymovirus	Cucumber soil-borne carmovirus
Brinjal mild mosaic potyvirus	Cymbidium mosaic potexvirus
Broad bean wilt fabavirus	Cymbidium ringspot tombusvirus
Broccoli necrotic yellows cytorhabdovirus	Daphne X potexvirus
Caraway latent nepovirus	Datura Colombian potyvirus
Carnation ringspot dianthovirus	Datura distortion mosaic potyvirus
Carrot mosaic potyvirus	Datura innoxia Hungarian mosaic potyvirus
Cassava African mosaic bigeminivirus	Datura mosaic potyvirus
Cassava common mosaic potexvirus	Datura yellow vein nucleorhabdovirus
Cassava green mottle nepovirus	Dioscorea latent potexvirus
Cassava Indian mosaic bigeminivirus	Dogwood mosaic nepovirus
Cassia mild mosaic carlavirus	Dulcamara mottle tymovirus
Cauliflower mosaic caulimovirus	

Eggplant mosaic tymovirus	Pittosporum vein yellowing
Eggplant mottled crinkle tombusvirus	nucleorhabdovirus
Eggplant severe mottle potyvirus	Plantain X potexvirus
Elderberry latent carmovirus	Plum American line pattern ilarvirus
Epirus cherry ourmiavirus	Poinsettia mosaic tymovirus
Eucharis mottle nepovirus	Poplar mosaic carlavirus
Euphorbia mosaic bigeminivirus	Potato 14R tobamovirus
Frangipani mosaic tobamovirus	Potato Andean latent tymovirus
Grapevine chrome mosaic nepovirus	Potato Andean mottle comovirus
Guar top necrosis virus	Potato aucuba mosaic potexvirus
Henbane mosaic potyvirus	Potato black ringspot nepovirus
Hippeastrum mosaic potyvirus	Potato leafroll luteovirus
Hop American latent carlavirus	Potato M carlavirus
Ivy vein clearing cytorhabdovirus	Potato mop-top furovirus
Kalanchoe isometric virus	Potato T trichovirus
Kennedy yellow mosaic tymovirus	Potato U nepovirus
Kyuri green mottle mosaic tobamovirus	Potato X potexvirus
Lamium mild mottle fabavirus	Primula mottle potyvirus
Lettuce necrotic yellows	Prune dwarf ilarvirus
cytorhabdovirus	Radish mosaic comovirus
Lucerne Australian latent nepovirus	Raspberry ringspot nepovirus
Maracuja mosaic tobamovirus	Red clover necrotic mosaic dianthovirus
Melandrium yellow fleck bromovirus	Ribgrass mosaic tobamovirus
Melilotus mosaic potyvirus	Rose tobamovirus
Melon Ourmia ourmiavirus	Rubus Chinese seed-borne nepovirus
Milk vetch dwarf nanavirus	Scrophularia mottle tymovirus
Narcissus latent macluravirus	Serrano golden mosaic bigeminivirus
Narcissus mosaic potexvirus	Solanum apical leaf curling
Neckar River tombusvirus	bigeminivirus
Nerine latent carlavirus	Solanum nodiflorum mottle sobemovirus
Ononis yellow	Sonchus cytorhabdovirus
mosaic tymovirus	Sowbane mosaic sobemovirus
Parsnip yellow fleck sequivirus	Soybean crinkle leaf bigeminivirus
Pea early browning tobavirus	Spring beauty latent bromovirus
Pea streak carlavirus	Strawberry latent ringspot nepovirus
Peanut chlorotic streak caulimovirus	Sunn-hemp mosaic tobamovirus
Peanut stunt cucumovirus	Sweet potato mild mottle ipomovirus
Peanut yellow spot tospovirus	Sweet potato ringspot nepovirus
Pelargonium leaf curl tombusvirus	Sweet potato yellow dwarf ipomovirus
Pelargonium line pattern carmovirus	Tamus latent potexvirus
Pepino mosaic potexvirus	Telfairia mosaic potyvirus
Pepper mild mottle tobamovirus	Tobacco etch potyvirus
Pepper Moroccan tombusvirus	Tobacco leaf curl bigeminivirus
Pepper ringspot tobavirus	Tobacco mild green mosaic tobamovirus
Pepper Texas bigeminivirus	Tobacco mosaic satellivirus
Pepper veinal mottle potyvirus	Tobacco mosaic tobamovirus
Physalis mosaic tymovirus	

Tobacco mottle umbravirus	Tomato pseudo curly top
Tobacco necrosis necrovirus	hybrigeminivirus
Tobacco necrotic dwarf luteovirus	Tomato ringspot nepovirus
Tobacco ringspot nepovirus	Tomato spotted wilt tospovirus
Tobacco streak ilarvirus	Tomato top necrosis nepovirus
Tobacco stunt varicosavirus	Tomato vein clearing nucleorhabdovirus
Tobacco vein-distorting luteovirus	Tomato yellow leaf curl bigeminivirus
Tobacco yellow dwarf monogeminivirus	Tomato yellow mosaic bigeminivirus
Tomato Australian leafcurl	Tulip halo necrosis virus
bigeminivirus	Turnip crinkle carmovirus
Tomato black ring nepovirus	Turnip mosaic potyvirus
Tomato bushy stunt tombusvirus	Ullucus mild mottle tobamovirus
Tomato golden mosaic bigeminivirus	Watermelon mosaic 2 potyvirus
Tomato mild mottle potyvirus	White clover mosaic potexvirus

(URL-31)

6.9 Varieties:

There are two varieties of this species of *Datura*, one with a green stem and white flowers, the other with a dark-reddish stem, minutely dotted with green and purplish flowers, striped with deep purple on the inside. The latter is now considered as a distinct species, being the *D. tatula* of Linnaeus. The leaves are mostly of a deeper green, and have purplish foot-stalks and mid-ribs. (URL-3)

6.10 Propagation:

Sow the seed in individual pots in early spring in a greenhouse. Put 3 or 4 seeds in each pot and then if necessary to the best plant. The seed usually germinates in 3 - 6 weeks at 15°C. Plant out in late spring or early summer, after the last expected frosts.

Especially in areas with hot summers, it is worthwhile trying a sowing outdoors in situ in mid to late spring. (URL-32)

Propagation Methods:

From herbaceous stem cuttings

From woody stem cuttings

From softwood cuttings

From semi-hardwood cuttings

From seed; direct sow outdoors in fall

From seed; winter sow in vented containers, coldframe or unheated greenhouse

From seed ; germinate in a damp paper towel. (URL-33)

6.11 Tissue culture:

From sterile root cultures of *D. stramonium*, an NADP (H)-specific tropine dehydrogenase has been isolated and characterized. The enzyme catalyzes the reversible

and stereospecific oxidation of tropine and related tropane-3 alpha-ols to the corresponding ketone. Isomeric pseudotropine (tropane-3 beta-ol) is neither accepted as substrate nor produced in the reverse reaction. It is assumed that this dehydrogenase is involved in the biosynthesis of tropane alkaloids. (URL-34)

'Hairy root' cultures of *D. stramonium* were established following infection of aseptic leaves with *Agrobacterium rhizogenes*. Transformation was confirmed by Southern blotting using [(32) P]-labelled fragments of the T-DNA as probes. The transformed cultures grew in the absence of added phytohormones and cell mass increased 55-fold during 28 days incubation. Hyoscyamine was a major component of the alkaloid fraction and accounted for at least 0.3% of the dry matter, comparable to pot-grown plants from which the cultures were initiated. Production of hyoscyamine followed growth during the first 15 days of incubation, but continued to increase during the early part of stationary phase. The alkaloid was retained almost entirely in the root tissue. The effects of medium composition and pH on growth and hyoscyamine production are reported. (URL-35)

Primary nitrogen metabolism in transformed root cultures of *Datura stramonium* was observed by *in vivo* ¹⁵N NMR. Treatment of the root cultures with the plant growth regulators α -naphthaleneacetic acid (NAA) and kinetin caused a de-differentiation of the root tissue, together with perturbation of primary and secondary nitrogen metabolism. The levels of newly-synthesized glutamine and glutamate during ammonium assimilation were depleted relative to control cultures, whereas GABA biosynthesis was enhanced. Although GABA production could be stimulated by a decrease in cytoplasmic pH (whether imposed artificially or induced by hypoxia), observation of the roots during phytohormone treatment by ³¹P NMR showed that the cytoplasmic pH remained stable, indicating that the perturbation of nitrogen metabolism in the de-differentiated roots must be due to other causes. (Ford *et al.*, 1996)

Treatment of suspension cultures of *D. stramonium* with Cd²⁺ ions in low concentration induced synthesis of tropane alkaloids. The best induction was achieved at about 20 μ mol. While production was rapid over the first 9 days in medium with 44 μ mol Cd, little or no further increment was found thereafter. We have demonstrated that, elicitation is however effective only by the low concentration of Cd. It has been established in *D. stramonium* cultures that elicitation of tropane alkaloids includes decrease of their composition and it seems probable that similar mechanisms are active in *D. stramonium* hairy roots.

Table 8:- Tropane alkaloids in suspension cultures of *D. stramonium* L.

SN	Compound
1	Hygrin
2	3- α -Tropin
3	3- α -Acetyltropin
4	3- α -Tigloyltropin
5	Cuscohygrin
6	3- α -phenylacetyltropin
7	Apoatropin

8	Methylhyoscyamin
9	Hyoscyamin
10	3- α , 6- β -ditygloiltropin
11	Methylscopolamin

Investigation of production of p-hydroxymethylphenol-beta-D-glucoside (gastrodin) through biotransformation by plant cell suspension cultures was done by using cell suspension cultures of *D. stramonium* to convert the exogenous p-hydroxybenzaldehyde into gastrodin was conducted and the converted compounds were separated with a combination of multi-chromatography. Their chemical structures were determined on the basis of spectral analysis and chemical evidence. The conversion procedure of p-hydroxybenzaldehyde into gastrodin by *D. stramonium* cell suspension cultures was established. The synthesized gastrodin (II) was isolated from the fermental liquor and identified by spectral analysis. At the same time, the p-hydroxybenzyl alcohol (I) converted through biotransformation of p-hydroxybenzaldehyde by cell suspension cultures of *D. stramonium* was also isolated and identified. Two compounds were also isolated from the cell cultures and they were identified as beta-D-furanoallulose (III) and n-butyloxystyryl-beta-D-pyranoallulose (IV). Hence *D. stramonium* grown in suspension cultures can convert exogenous p-hydroxybenzaldehyde into the corresponding gastrodin. (URL-36)

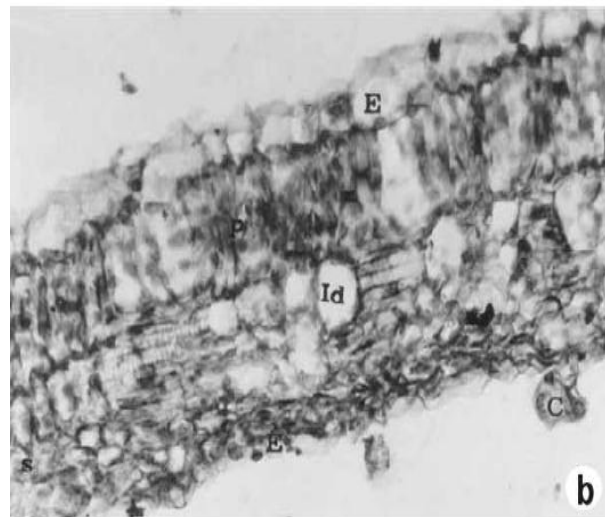
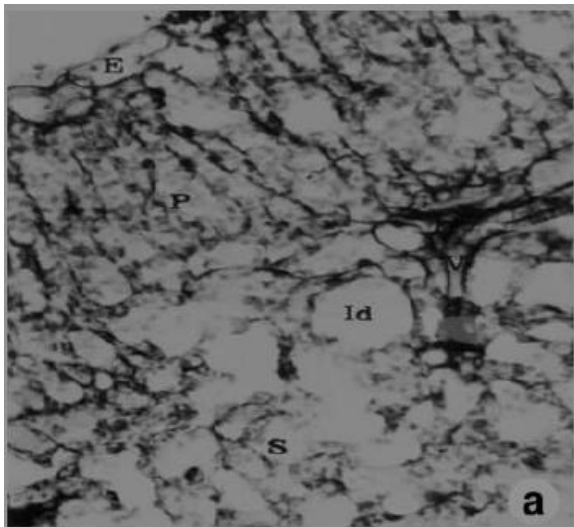
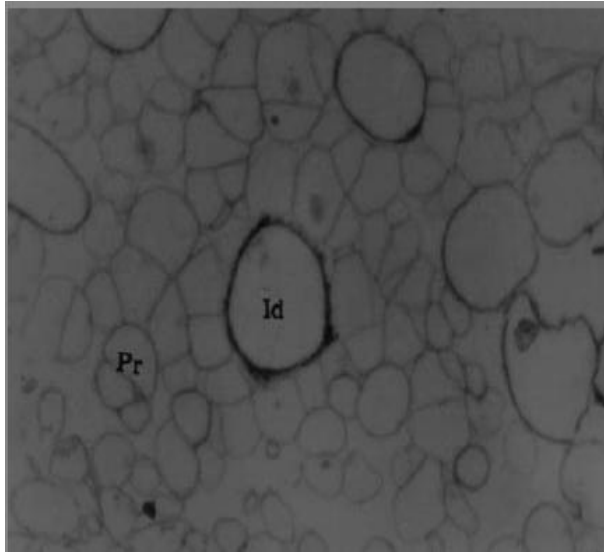


Figure-20 Idioblast cells (Id) originated from semi-hyaline callus of *D. stramonium*. Note their spherical or oval shape, thick cell wall and large central vacuole. Adjacent cells are smaller, condensed and smooth, whereas idioblast cells are rough. Pr – parenchyma. × 400. Idioblast cells (Id) in leaves of *D. stramonium* adjacent to vessel bundles and subsidiary veins, and in interstices of scalenous chlorenchyma. (a) Transverse section of leaf at time of inoculation, (b) Transverse section of leaf cultured in vitro. E – epidermis; S – scalenous chlorenchyma; C – cork. × 400.

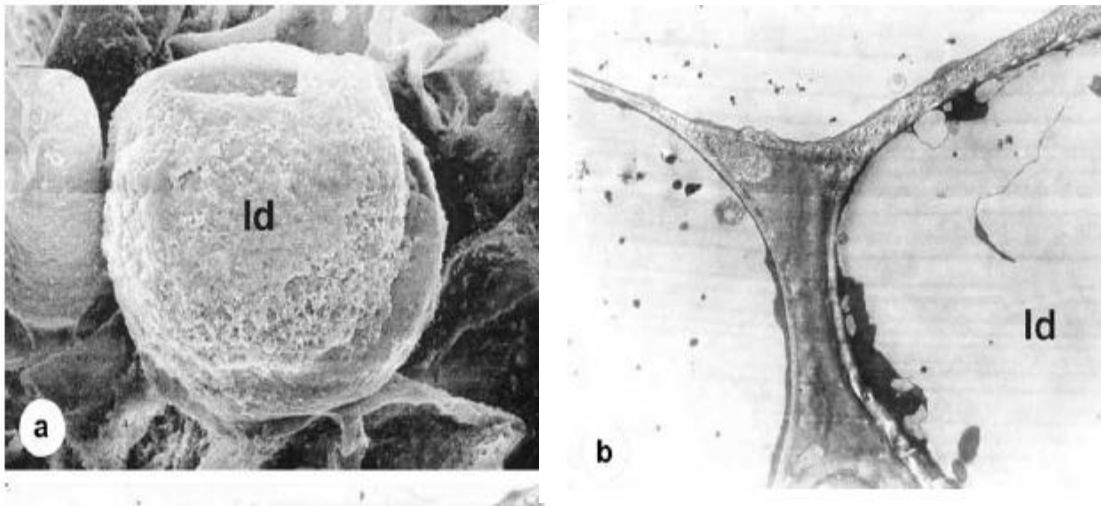


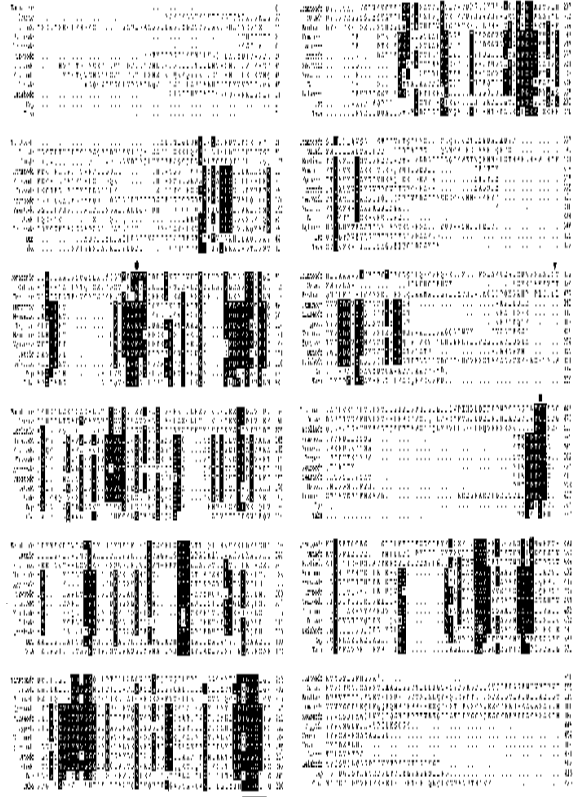
Figure -21 Micrograph of idioblast cells in semi-hyaline callus originated from basal part of leaf of *Datura stramonium*. a) SEM, × 1400, (b) TEM, × 4400 (Iranbakhsh *et al.*, 2006)

A cDNA for a plant ornithine decarboxylase (ODC), a key enzyme in putrescine and polyamine biosynthesis, has been isolated from root cultures of the solanaceous plant *Datura stramonium*. Reverse transcription-PCR employing degenerate oligonucleotide primers representing conserved motifs from other eukaryotic ODCs was used to isolate the cDNA. The longest open reading frame potentially encodes a peptide of 431 amino acids and exhibits similarity to other eukaryotic ODCs, prokaryotic and eukaryotic arginine decarboxylases (ADCs), prokaryotic *meso*-diaminopimelate decarboxylases and the product of the *tabA* gene of *Pseudomonas syringae* cv. *tabaci*. Residues involved at the active site of the mouse ODC are conserved in the plant enzyme. The plant ODC does not possess the C-terminal extension found in the mammalian enzyme, implicated in rapid turnover of the protein, suggesting that the plant ODC may have a longer half-life. Expression of the plant ODC in *Escherichia coli* and demonstration of ODC activity confirmed that the cDNA encodes an active ODC enzyme. This is the first description of the primary structure of a eukaryotic ODC isolated from an organism where the alternative ADC route to putrescine is present.

```

1 GCACGAGGAAACACTCAATATTCATATATACATATATATTTGAATCCCAATTTCTTGT
61 TTTCCTTGGATTCCTCTCTCTTGGATGGCCGAGACAGTCAATCGTTCCGGGTGA
121 ACCCGGGCCCTCTCAGTCCCAATCGCGGAGCTACTCTCCACCGCGCGGAGA
181 ACGACCACACGAAAAGTTGTCCCTCTCAAGAGATGCCCTCAGGATTCATGGTT
241 CAATCATCCACGAAATACAAGATGAAAGCGCCCTTATGTGCTGGATTGGGAG
301 AAGTTGCTCCCTTATGGATCAAGAAAGCGGTTTACCAAAATTCGCTCCATTTAAG
361 CAGTTAAGTGAACCCAGAACCTTCATTTCTGTCCTATGCTGCTATGGGTCCAATT
421 TTGATTTGCTAGCCGTCTGAAATGAGTATGTTGTCACCTGGATTCACCGGACC
481 GTATGCTTTCCGCAACCCATTAAGCGGAAATCCGACATAATTTCCGCGCAAAAGTTG
541 GGGTAAATCCAGACCTTCGATTCGAGGAGGAGTTTACAAGATCGTAAAGTCAAC
601 CGAAATCGGAGCTGTCTCGAATCAACCCATGGACGCAATGCAAGATGCCCTA
661 TGGACCTAAATACCGGCACTGCTGAAGAGTGGAGCCCTGCTCCGACCGCTCAAG
721 CCGCCAGCTAACCGTCTCTGGGTTTCTTCCACATCGGACGCGAGCCGATCCA
781 AAGCTTATTTAGGACCATAGCTCGCGGAGGAGTTTTCGAAACAGCGGCTCGTTC
841 GTATTCGAAAATACCGGTTTACGATCGCGGTTGATTTACCTCCGCAAAATCCA
901 CCACGCCCTCCGCGCTGTCAGATCGAGCCGAGCAACCTTCCATGACGCAAGAGC
961 TAACAATCATCGCCGACCGGTTCTTTCGAGAGACCGGCTTCACTTTAGCCAAA
1021 CCATTTATCGGAAACAGGTTGAGGGGAGAAATTAAGAGAACTCGATCAGACCGCTT
1081 ACGGATCGTAACTGTGTACTTTACGACCACCGGAGCGTGAACCGGACCGCTTAGCGT
1141 GCATGCGAATCGTAGTAACTCACTCGCGGGTCCGAAAACGTTTCCGTCGACTGTAT
1201 TCGGGCCACCTGTAACCTTGAATGACTGTGTTAAGGATTACGAGTTACCGGAGCTAC
1261 AGGTAAATGACTGGCTGATTTTTCATTAATGGGTGCTTACACAAAAGCTGCTGGTCCA
1321 ACTTCAATGGATTAACACATCGCCATGTTTACTCACCTTCTTATGCTTATCTTAGCT
1381 GATAAAATCACCACCAATAGAATCTAATAGCAGCGTGGTTGTAATTTTTCTTTTTT
1441 GGGGTTTTTTTCTAATTTCTTTTTTTTTTTGTAATTTATTTTCCAGTCACTGT
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1561 TAGAAGTCAATTAATTAATAAAAAAAAA 1587

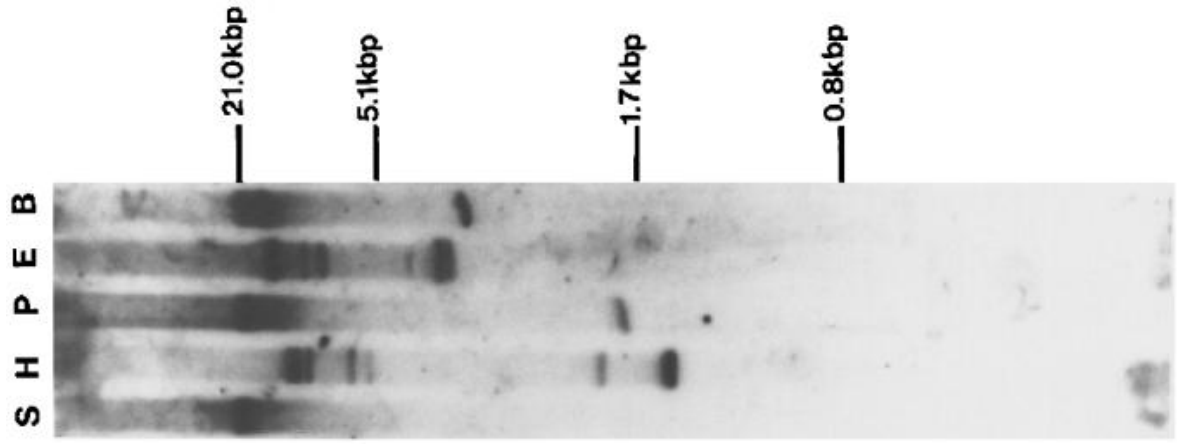
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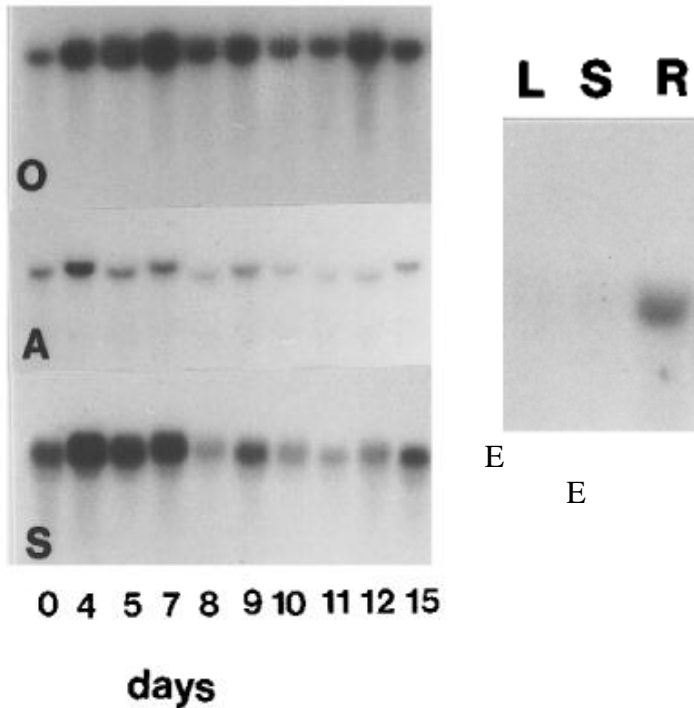
A

B

You can look these two figures at high resolution on <http://www.biochemj.org/bj/314/0241/bj3140241f01.htm> and <http://www.biochemj.org/bj/314/0241/bj3140241f02.htm> respectively (Accessed on Oct.17, 2008)



C



D

Figure 22 A. Nucleotide sequence and predicted amino acid sequence of the *Datura* ODC, B. Alignment of the *Datura* ODC amino acid sequence with other eukaryotic ODCs, plant ADCs and *E. coli* ADC, DapDC and the deduced sequence of the product of the *tabA* gene of *Ps. syringae* cv. Tabaci, C. Southern analysis of the *Datura* ODC genomic sequences, D ODC transcript levels in *Datura* organs, E. Time course of ODC, ADC and SAMDC transcript accumulation during growth of *Datura* transformed root cultures. (Michael *et al.*, 1996)

6.12 Harvesting:

The commercial drug as imported into Great Britain consists of the leaves and young shoots, collected while the plant is in flower, and subsequently dried, and containing the shrivelled, bristly young fruits, tubular calyx, and yellowish corolla, but the official description, for medicinal purposes, permits of the use of the leaves only. The leaves should be gathered when the plant is in full bloom and carefully dried. The United States Pharmacopoeia considers that they may be gathered at any time from the appearance of the flowers till the autumnal frosts. In this country they are generally harvested in late summer, about August, the crop being cut by the sickle on a fine day in the morning, after the sun has dried off the dew, and the leaves stripped from the stem and dried carefully as quickly as possible, as for Henbane. Stramonium seeds are official in a number of Pharmacopoeias. The thorny capsules are gathered from the plants when they are quite ripe, but still green. They should then be dried in the sun for a few days, when they will

split open and the seeds can be readily shaken out. The seeds can then be dried, either in the sun or by artificial heat. (URL-1) The total alkaloids content is considerably less after a rainy period than after clear weather. Indeed, the difference is so marked, that the drug, to be rich in alkaloids, needs to be collected after a period of clear days. Leaves collected in the early morning contain more alkaloids than those picked in the evening and leaves dried in shade contain more alkaloids than those dried in the sun. Leaves which are allowed to dry on the plant contain more alkaloids than those dried after clipping; the increase is accompanied by a decrease in the alkaloids content of root and stem, suggesting relocation. The alkaloids content of picked leaves, exposed to a temperature of 100 °C for 15 minute to destroy the enzymes as a preliminary to drying, is higher than that of leaves not so treated. The removal of flower buds increases the yield of leaves. (Anonymous, 2003)

6.13 Commercial value:

In the early 1990s, Thorn Apple sold its fresh pork and manufacturing products to more than 900 customers in the United States, Canada, and several Pacific Rim countries. International sales for fiscal year 1992 were 1.5% of the company's total sales.

Thorn Apple's performance in the mid-1990s lagged behind that of the early 1990s, as net sales stagnated from fiscal 1992 through fiscal 1995 and net income fell each year, from the high of \$21.1 million in 1992 to just \$5.3 million in 1995. Although net sales increased dramatically in fiscal 1996, the increase was largely attributable to a major acquisition and meanwhile the company posted a net loss of \$21.7 million.

In an early move in the restructuring, Thorn Apple in early 1995 recorded a \$7.9 million restructuring charge to close Tri-Miller Packing, whose facilities were considered redundant after the expansion of the company's Grand Rapids, Michigan, plant, and to move and consolidate the corporate headquarters.

Shortly thereafter, in May 1995, Thorn Apple paid \$64.6 million to acquire the Wilson Foods Retail Division from Food brands America, Inc. Nevertheless, the size of Wilson Foods, which had annual sales of about \$220 million, made the integration of the new brands, products, and facilities difficult to manage, leading to the fiscal 1996 net loss of \$21.7 million.

Financial results for the fiscal year ending May 30, 1997, backed up this confidence as Thorn Apple posted a net loss of just \$3.2 million, which even took into account a \$5 million restructuring charge for costs associated with suspending a joint production agreement at a production facility located in Council Bluffs, Iowa. Although net sales fell slightly to \$955.8 million, full-year cash flow amounted to \$24.3 million, a vast improvement over the negative \$10.7 million of fiscal 1996. (URL-37)

7. CHEMICAL CONSTITUENTS

7.1 Alkaloids:

The seat of synthesis of alkaloids is the root; this has been established by the study of alkaloid accumulation in reciprocal grafts of *Datura* with tobacco and tomato. Scions of tobacco and tomato grafted on *Datura* Stocks contain stramonium alkaloids, while *Datura* scions grafted on tobacco and tomato root –stocks contain no alkaloids. The alkaloids in the leaves are chiefly located in the epidermis, particularly in the upper epidermis and in the phloem parenchyma; the midrib contains the higher concentrations of alkaloids than the petiole. The upper leaves and branches are richer in alkaloids than those near the base. (Anonymous, 2003)

Table 9:- Percentage of atropine and scopolamine alkaloids in different parts of *Datura stramonium* plant quantified by GC/MS (Gas chromatography/ Mass spectroscopy) method

Developmental stage and organ	Atropine	Scopolamine	Total
Leaf in vegetative phase	0.037	0.090	0.127
Petiole in vegetative phase	0.080	0.042	0.122
Capsule	0.064	0.034	0.098
Stem in generative phase	0.070	0.023	0.093
Stem in vegetative phase	0.070	0.023	0.093
Petiol in generative phase	0.062	0.020	0.082
Root in generative phase	0.056	0.013	0.069
Leaf in generative phase	0.030	0.020	0.050
Root in vegetative phase	0.045	0.000	0.045
Seed	0.000	0.020	0.020

(Iranbakhsh *et al.*, 2006)

7.2 Variation of Alkaloids in diploid and tetraploid hairy root culture of *D. stramonium*

Hairy root cultures were obtained from diploid and induced tetraploid plants of *D. stramonium* and analyzed by gas chromatography/mass spectrometry. Twenty alkaloids (19 for diploid and 9 for tetraploid hairy root cultures) were identified. A new tropane ester 3-tigloyloxy-6-propionyloxy-7-hydroxytropane was identified on the basis of mass spectral data. Hyoscyamine was the main alkaloid in both diploid and tetraploid cultures. In contrast to diploid hairy roots, the percentage contributions of the alkaloids, with exceptions for hyoscyamine and apoatropine, were higher in the total alkaloid mixture of tetraploid hairy roots.

Table 10:- Alkaloids identified in diploid (2n) and tetraploid (4n) hairy roots cultures of *D. stramonium*

	Rt [min]	M ⁺	% of the alkaloid mixture	
			2n	4n
Hygrine (1)	4.14	141	0.79	2.76
Tropinone (2)	5.18	139	0.15	0.34
3-Acetoxytropane (3)	7.02	183	2.47	28.43
Methylecgonine ¹ (4)	9.10	199	0.48	–
3-Hydroxy-6-acetoxytropane (5)	9.54	199	0.40	–
3-Acetoxy-6-hydroxytropane (6)	9.62	199	–	1.55
3,6-Diacetoxytropane (7)	10.38	241	1.22	2.54
3-Tigloyloxytropane (8)	11.03	223	0.36	1.18
3-Tigloyloxy-6-hydroxytropane (9)	13.12	239	0.34	–
3-Hydroxy-6-tigloyloxytropane (10)	13.23	239	0.22	–
3-Tigloyloxy-6-propionyloxy-7-hydroxy-tropane ² (11)	14.02	311	1.04	–
Phenylacetoxytropane (12)	14.29	259	0.51	–
Apoatropine (13)	15.11	271	7.19	5.73
Alkaloid D (14)	16.05	–	0.64	–
Hyoscyamine (15)	16.53	289	78.75	56.60
3,6-Ditigloyloxytropane (16)	16.68	321	1.14	–
3-(3'-Acetoxytropoyloxy)tropane (17)	17.24	331	0.43	0.87
Alkaloid E (18)	17.88	319	2.17	–
3-Tropoyloxy-6-acetoxytropane ³ (19)	18.51	347	0.82	–
6-Tigloyloxyhyoscyamine (20)	18.80	387	0.89	–

(Berkova *et al.*, 2003)

One pharmacognostical application has been the determination of the complete amino acid sequence of one of the iron sulphur ferredoxins present in varieties of *D. stramonium*. (Evans, 2008)

7.3 Chemical composition:

Whole plants contains 0.26% alkaloids. The seeds of *Datura stramonium* contain the alkaloid *daturine*, said to be combined with malic acid . It was first obtained pure and crystallized by Geiger and Hesse, in 1833, who also found it to occur in the leaves and the herb. It is now known to be a mixture of several alkaloids. Von Planta (1850) pronounced daturine to be identical with *atropine*, the principal belladonna alkaloid. Ladenburg differentiated daturine into atropine and *hyoscyamine*, the latter alkaloid predominating. E. Schmidt, however, contended that atropine predominates. It is accepted that *hyoscyamine* is the principal *Datura* alkaloid; other alkaloidal constituents being *atropine* and *hyoscine*. The seeds of *Datura stramonium* contain fatty oil (25 per cent), from which a new fatty acid, *daturic acid* (C₁₇H₃₄O₂), was isolated by Gérard. It stands intermediate between palmitic and stearic acids. *Stramonin* is an indifferent, crystallizable, tasteless body, obtained from the seeds by Trommsdorff. As to the quantity of total alkaloids in various parts of the plant, Dr. A. R. L. Dohme concludes that the stems contain more alkaloid (0.3 to 0.4%, volumetrically) than even the seeds (0.25 to 0.29%), and the latter more alkaloid than the leaves (0.21 to 0.23%, and 0.27% for green leaves), etc. Herb gathered. in July and August contained more alkaloid than that collected in June. J. B. Nagelvoort (1897) finds the flowers of *D. alba*, L., to contain a notable quantity of total alkaloids. (Khare, 2007)

Table 11:- Chemical constituents of *D. stramonium*

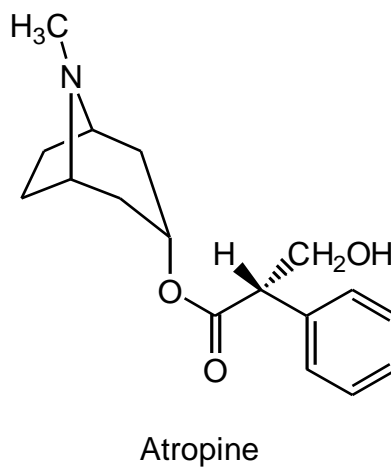
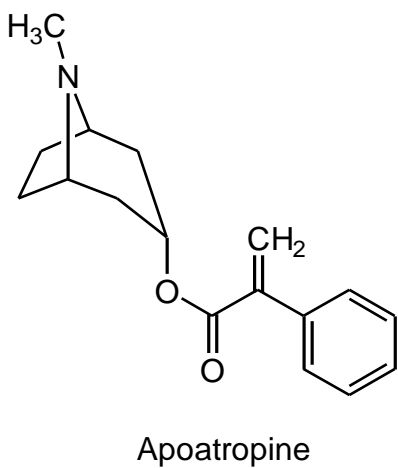
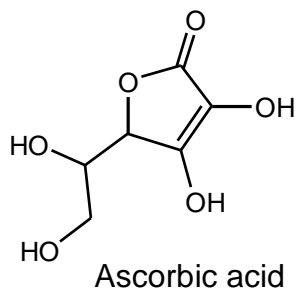
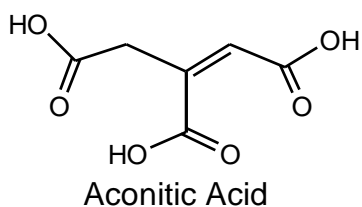
Chemical constituents	Plants parts
3-alpha, 6-beta-ditigloyloxytropane	Plant
4-hydroxylobin	Plant
Acetic-acid	Plant
Acetone	Leaf
Aconitic-acid	Plant
Alkaloids	Fruit 4,600 ppm; leaf 2,500 - 5,100 ppm Plant 1,000 - 5,000 ppm; root 2,100 ppm; Seed 1,000 ppm; stem 2,500 - 2,600 ppm
Alpha-ketoglutaric-acid	Plant
Apoatropine	Plant
Ascorbic-acid	Plant
Atropamine	Plant
Atropine	Plant
Atropinesterase	Plant
Butanol	Leaf

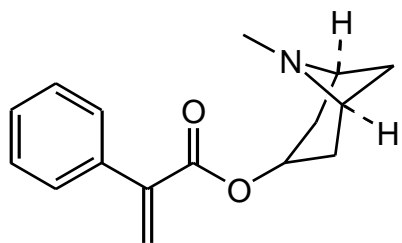
Caffeic-acid	Plant
Capsidol	Plant
Citric-acid	Plant 750 ppm
Cuscohygrine	Leaf
Datugen	Plant
Datugenin	Plant
Ditigloyl-d-dehydroxytropane	Plant
Eo	Leaf 450 ppm
Esculetin	Plant
Ethanol	Plant
Fat	Seed 150,000 - 300,000 ppm
Ferulic-acid	Plant
Fluro <i>Daturatine</i>	Plant
Formaldehyde	Plant
Formic-acid	Plant
Fumaric-acid	Plant
Galactose	Leaf
Glucose	Leaf
Glycolic acid	Plant
Homofluro <i>Daturatine</i>	Plant
Hyoscine	Leaf 550 - 2,500 ppm; seed 1,200 - 5,000 ppm
Hyoscyamine	Seed 80 - 490 ppm
Isobutyraldehyde	Plant
Lactic- acid	Plant
Lignoceric-acid	Plant
Linoleic-acid	Seed 22,500 - 45,000 ppm
Malic acid	Plant 2,120 ppm
Meteloidine	Leaf
Methanol	Leaf
Neochlorogenic-acid	Plant
Nicotine	Plant
Oleic-acid	Seed 93,000 - 186,000 ppm
Palmitic-acid	Seed 15,000-30,000ppm
Potassium-nitrate	Plant
Propionaldehyde	Plant
Protein	Seed 140,000-194000ppm
Putrescine	Plant
Rutin	Plant
Scopin	Plant

Scopol	Seed 5 3-3050
Scopoletin	Plant
Scopolin	Plant
Sitosterol	Seed
Sophorose	Leaf
Stearic-acid	Plant
Succinic-acid	Plant
Tannin	Plant 70,000
Tigloylmeteloidin	Plant 5-25ppm
Umbelliferone	Plant
Vitastramonolide	Plant

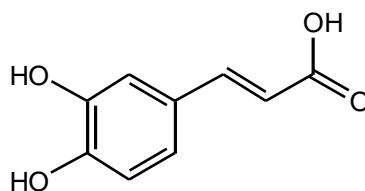
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7.4 Structures of selected compounds:

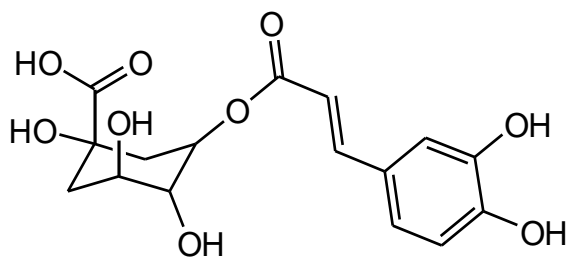




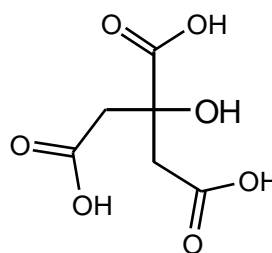
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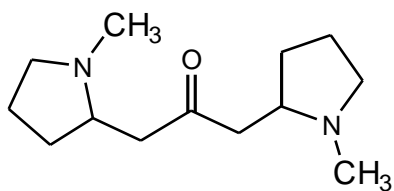
Caffeic acid



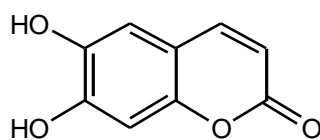
Chlorogenic acid



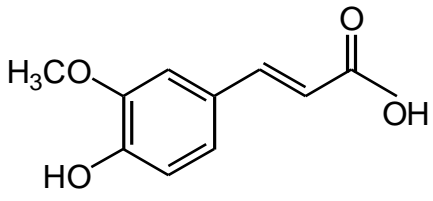
Citric acid



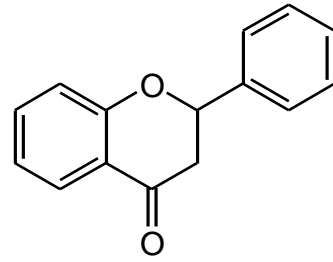
Cuscohygrine



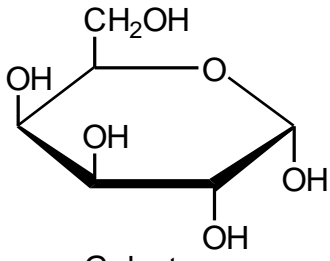
Esculetin



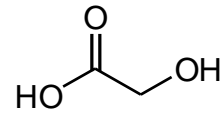
Ferulic acid



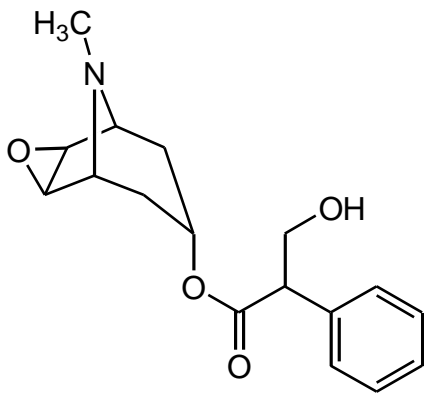
Flavonoid



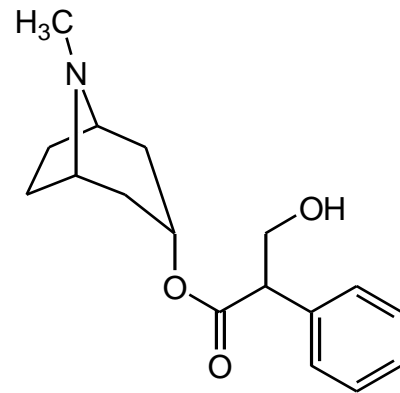
Galactose



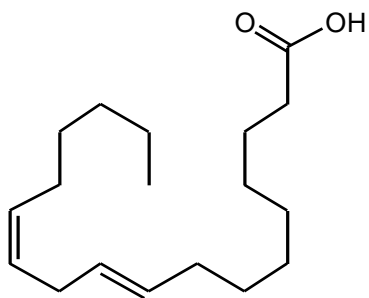
Glycolic acid



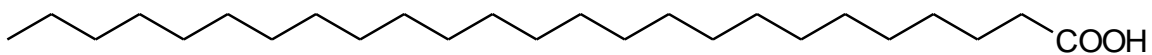
Hyoscine



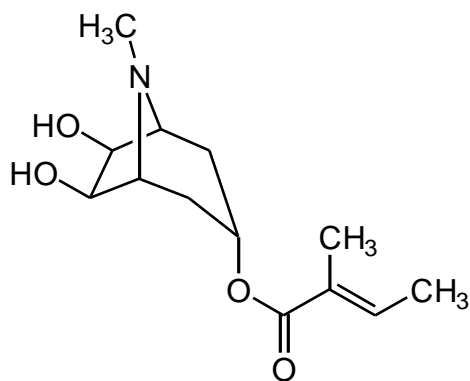
Hyoscyamine



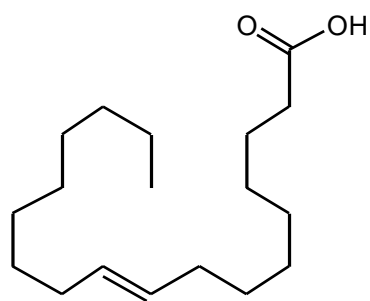
Linoleic acid



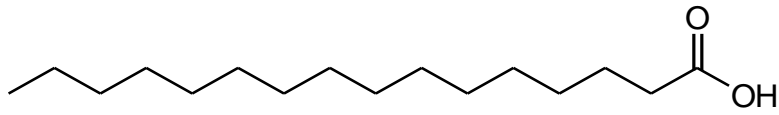
Lignoseric acid



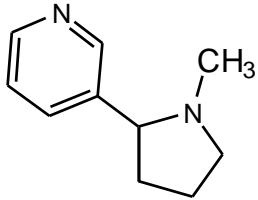
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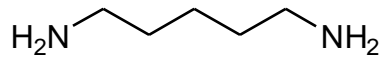
Oleic acid



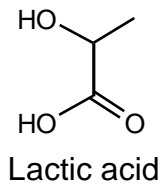
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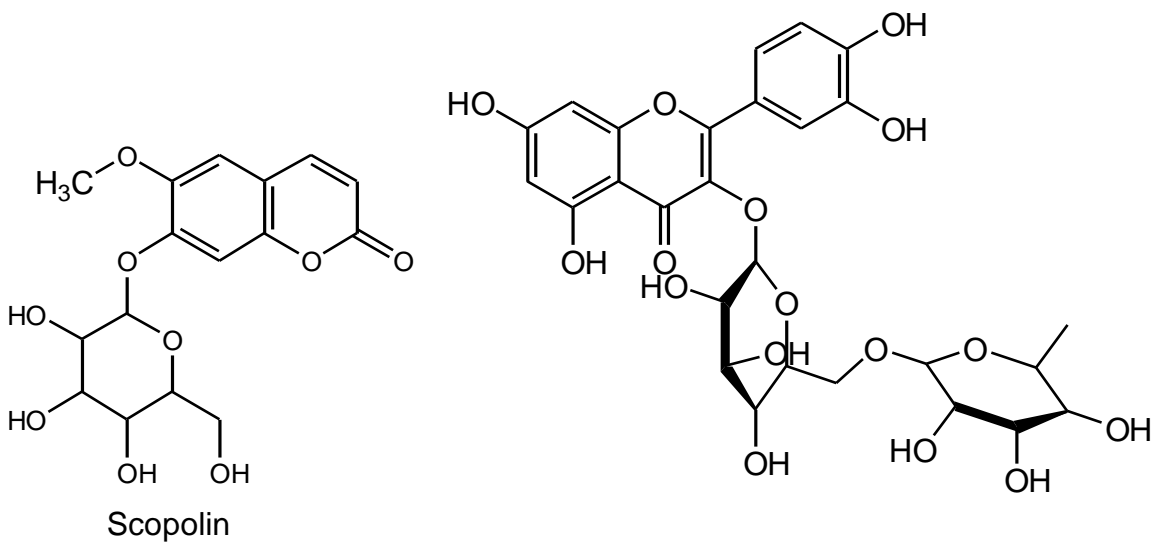
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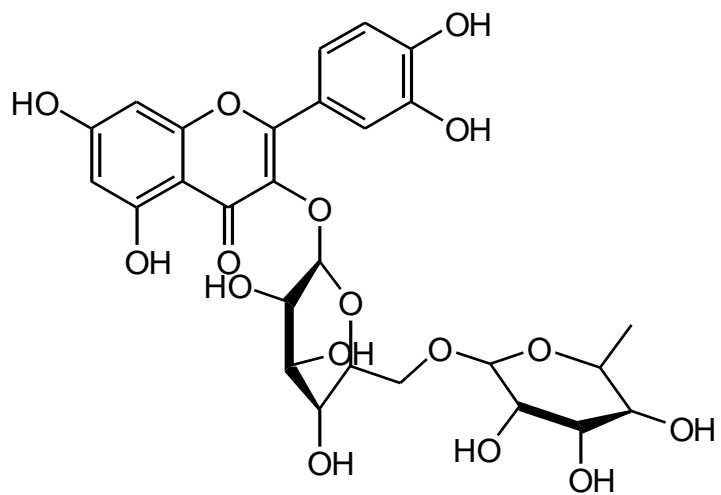
Putrescine



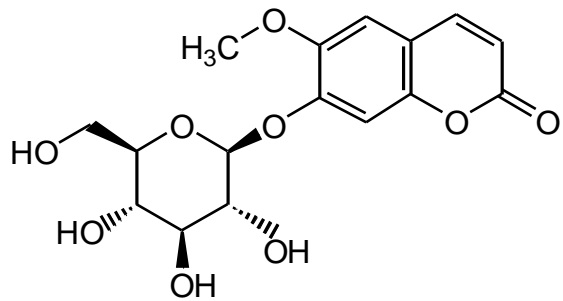
Lactic acid



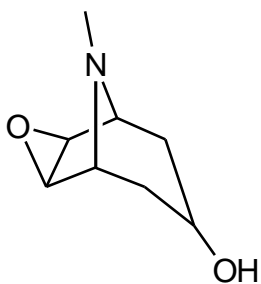
Scopolin



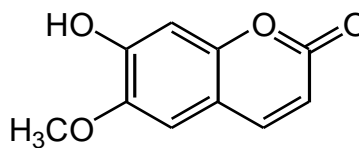
Rutin



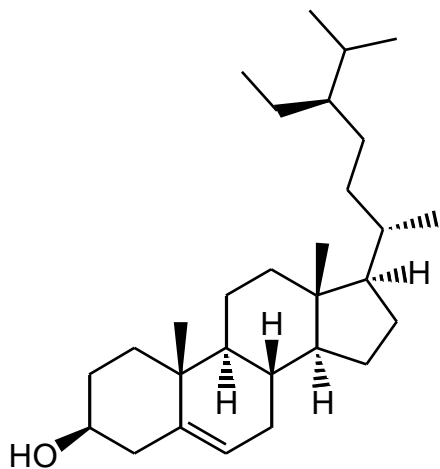
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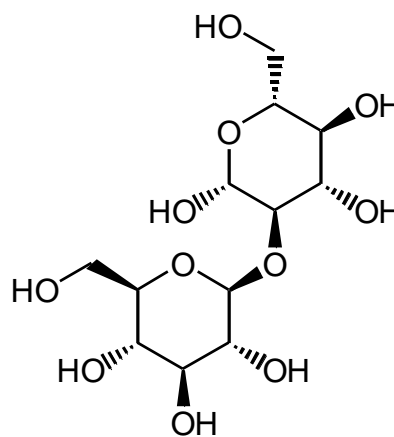
Scopin



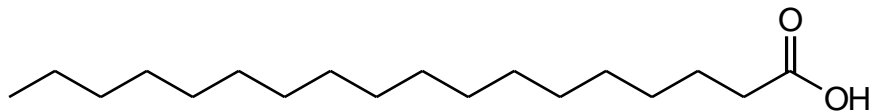
Scopoletin



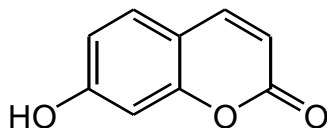
Sitosterol



Sophorose



Stearic acid



Umbeliferone

Figure-23 Structures of selected compounds

8. USES

8.1 Mythological importance:

Among Native Americans, *Datura* has been regarded as a scared plant, used to induce visions and visit with the gods. The complete spectrum of these uses have been employed by the Zunis to commune with the Feathered Kingdom, Zuni Rain Priests put the powdered roots of *D. innoxia* in their eyes. Also, they chew the roots in order to ask the dead to parley with the spirits for rain. *Datura* has also been used in initiation rites for boys entering puberty. Initiates were made to fast; they then drank a decoction made from the roots. This decoction was often prepared ritually, to the accompaniment of singing. As the decoction began to take effect, each boy, in the care of an adult, was taken to a ceremonial enclosure. There the boys remained for several hours to several days, having visions, and learning to “unlive” their boyhood, becoming men. (URL-16)

Datura is referred to in ancient Indian literature as Shivashekhrea because the flowers are believed to be associated with Lord Siva. It was known to the ancient Hindu physicians. (URL-39)

8.2 Social value:

Datura was definitely used in the Old World, no where did it have as much application as in the New World. The seeds were used by ancient Peruvians in trepanning operations as an anesthetic and archeological evidence Indicates that these complex surgical procedures had a higher survival rate than one would expect. The use of enema syringes in Peru

dates back to 600-800 AD and could have contained *Datura* among other things, considering the vast herbal knowledge of the healers of this region. Wild and cultivated species of *Datura* were also used in other parts of western South America by indigenous peoples to induce partial intoxication, to control unruly children, and the plant was given in large doses along with tobacco to women and slaves to deaden their senses before being buried alive with their dead husbands or masters. Extracts made from the bark, leaves, and seeds were also used in shamanistic rites and practices of this region.

The Aztecs also made use of *Datura*, specifically which they called ololuhqui "the magic plant," for all kinds of diseases including paralysis and as an ointment for cuts or wounds. The plant's narcotic effects were employed by Aztec shamans and priests to communicate with spirits, causing visions and stimulating people to dance, laugh, weep, sleep, or tell oracular prophecies. The seeds were considered sacred and kept on altars or in secret boxes and sacrificial offerings made to them by the Aztecs.

Zuni Indians and other cultures in the American Southwest and Mexican region used *Datura* as well and referred to it as toloache used to relieve pain during the setting of bones among other things. It was also taken by young boys in male initiation rituals and used in ceremonies following the death of a member of the tribe. Attitudes toward the plant varied among tribes from no special reverence to attribution of supernatural powers. But while knowledge of this plant was widespread among Native Americans, early colonialists were not as aware of its properties. (URL-40)

Dhattura seeds are frequently used in India for criminal purposes. (Shastri, 1997)

8.3 Traditional uses:

Jimsonweed or stinkweed (*D. stramonium* or *D. inoxia*) was familiar in North America before the Europeans arrived; the name, a corruption of "Jamestown weed," is derived from an incident in which it was eaten by seventeenth-century English colonists at Jamestown Virginia. The Aztecs used the drug *tolotzin* or *toloache* (*D. inoxia*) in divination and prognosis; other tribes still use this and other *Datura* species for sores and internal injuries, as a preparation for the hunt, in rain-dance rituals and puberty rites, and above all in witchcraft. California Indians personified toloache as a great shaman and used it in their vision quests for an animal spirit helper. It is still sold in Mexican markets as an aphrodisiac and medicine. A Spanish term for *Datura* is *hierba del diablo*, the devil's weed; under this name it is used, along with other "power plants": like peyote and a psilocybin mushrooms mixture, by the Yaqui Indian sorcerer Juan Matus in Carlos Castaneda's popular series of books. European investigators were once inclined to identify any unknown drug said to produce visions or hallucinations as the familiar *Datura*, and in the twentieth century the lysergic acid amide morning glory *ololiuqui* was misidentified in this way.

Plants containing atropine and scopolamine are also in common use in South America, from Columbia (*Methysticodendron amnesianum*) to southern Chile (*Latua pubiflora*, known as "the sorcerer's tree"). Various species of *Datura* and *Brunfelsia* are known in

the Amazon and the Andes as chamico, chiric sanango, borrachero, and maikoa, among other names. *Datura* is often one constituent of the Amazonian drink ayahuasca, and in coastal Peru it is sometimes added to the mescaline drink cimora made from the cactus *Trichocereus pachanoi*. The Jivaros of the Amazon use *Datura* as well as the harmaline drink natema; they regard *Datura* as stronger, more dangerous, and more suitable as a preparation for war. It is taken for spirit voyages to encounter the supernatural, but is not used in healing because the effects are so uncontrollable that the shaman cannot retain his ties to this world while journeying in the other one. Many South American *Datura* species unlike those of other regions are trees; interestingly, these tree *Daturas* are all, like coca, domesticated plants that are unknown in the wild. (URL-41)

Ritual use of *D. stramonium* is as widespread as the plant itself. In Mexico it is used exchangeably with *D. innoxia* as a visionary plant. Either a brew is made from the leaves, or the seeds are chewed and swallowed. Men will consume 27 (=3 X 9) seeds, while women only take 21 (=3 X 7). Unlike other visionary rituals this one can be performed in the daylight. In North America, the leaves of *D. stramonium* were mainly consumed as a smoking herb in mixtures of Kinnickinnick. In Europe it is mostly associated with witches' salves and -brews. Seeds were used to fortify beer in many countries. It is a very effective medicinal plant. As a poultice it can relieve rheumatism and muscle pains, smoked it will relieve asthma, and water extracts used externally may relieve migraines and headaches. (URL-42)

During ancient religious rituals in India, seeds were eaten by priests to induce hallucinogenic, prophetic and oracular states. European priests apparently drank *Datura* for the same reason. Some authorities believe the intoxicating smoke inhaled by Greek priests over 2,000 years ago at the Oracle of Delphi was *Datura*. Thieves in India and Europe used *Datura* for centuries as "knockout drops" to rob their stupefied victims.

In the East Indies, women fed *Datura* leaves to beetles, and then fed the poisonous dung to faithless lovers. Prostitutes in India added the seeds to their patron's drinks to induce sexual excitement. In fact, the use of *Datura* as an aphrodisiac spread throughout India, the Far East and Europe, and was an important ingredient in love potions and witches' brews. According to M.J. Harner, writing in *Hallucinogens and Shamanism* (1973), the use of a broom or staff was undoubtedly more than a symbolic Freudian act, for it served to apply the salves to sensitive vaginal membranes.

Greek and Roman physicians used *Datura* mixed with opium as a sedative and general anesthetic during surgery. In fact, the use of scopolamine (one of the alkaloids in *Datura*) plus morphine as an effective pain reliever and sleep inducer was common practice until the nineteenth century.

In 1905, Dr. Carl Gauss used extracts from *Datura* and morphine to induce twilight sleep treatment for women experiencing difficult child birth. The combination of scopolamine (one of the active alkaloids found in *Datura*) plus morphine was used for years as an effective pain reliever and sleep inducer.

Datura had a number of uses among Indian tribes of the United States, as well as Mexico and South America. Some aboriginal Indians in South America gave a *Datura*-alcohol beverage to wives and slaves of dead warriors and chieftains. The high priests of some tribes took *Datura* in order to communicate with spirits of the dead and with their gods.

Probably the best known use of *Datura* by several North American Indian tribes was the puberty ceremonial dances involving the drinking of a "toloache" (*Datura*) infusion by young boys preparing to enter manhood. (URL-43)

Helps in relieving the spasm of the Bronchitis in Asthma. It is used in treatment of Parkinsonism and Haemorrhoids. Young fruits are sedative and intoxicating. Leaves applied after roasting are useful in relieving pain. (URL-44)

In Europe the plant was used for witch craft, in salves or ointments. Throughout most European countries the seeds were used to brew beer. In Mexico various tribes (i.e. Opata, Seri) used *Toloache* in religious rituals. The weed was dried and smoked; the users were left on a high which consisted of hallucinations and total relaxation. Jimson weed was thought to cure those with deafness, soothe insomniacs, and release the heat of those with a fever. *D. stramonium* is thought to be one of two plants identified in 4,000-year-old rock paintings throughout the Pecos river region of Texas and northern Mexico, used by the Huichol Indians along with peyote to commune with the spirit world.

Hernandez (1959) reported that the Aztecs applied a decoction of leaves to the body for fever or administered as a suppository. The fruit and leaves were considered good for pain in the chest. If too much was taken, it was believed to cause insanity. In northwestern New Spain, the Opata rubbed a leaf of Taguaro on the painful area for "spleen disease". They believed it also matured tumors and abscesses. An ointment of the ground seeds and suet is rubbed on boils, pimples, and swellings; the powdered leaves are applied to hemorrhoids; and hot baths containing the plant give relief to colds and diarrhea. (URL-45)

8.4 Ethnomedicinal Uses:

In West Nepal, leaves along with the leaves of *Cannabis sativa* and stem of *Neopicrorhiza scrofulariflora*, are pounded with water and applied to treat headache in Jumla District. Seeds with grains of rice are crushed and taken to get relief from indigestion at Karnali zone.

In Central parts of Nepal freshly leaf is made warm and placed on the sprained part of the body repeatedly and regularly before going to bed for the alleged analgesic effect at Sindhupalchok district. Leaf juice is given with warm milk to expel intestinal worms, more particularly tapeworm. (Rajbhandari, 2001)

Seeds are mixed with palm oil and applied to severe cases of insect bites and stings. (Egharevba *et al.*, 2008)

In India the seeds have an acrid and bitter taste, used as tonic, febrifuge. The leaves after roasting are applied locally to relieve pain. (Gorsi *et al.*, 2002)

The women, in Pakistan, warm up 5 to 8 leaves in low fire and then tie on flagged breasts to bust them up. This treatment is continued for 15 days. Seeds (2 to 5) are added to a cup of green tea to relieve headache. (Hussain *et al.*, 2006)

8.5 Medicinal uses:

It is used as spasmolytic, antiasthmatic, anticholinergic, cerebral depressant, nerve sedatives. It controls spasms of bronchioles in asthma and temporary relief from parkinsonian tremor is also recorded (contraindicated with depressant drugs). If applied locally stramonium palliates the pain of rheumatism, neuralgia, also pain due to hemorrhoids, fistula, abscesses and similar inflammations. It also prevents motion sickness. Key application of *Datura* is in diseases of autonomic nervous system. *The British Herbal Pharmacopoeia* reported antispasmodic action of leaf and *Indian Herbal Pharmacopoeia* accepted it as expectorant and antispasmodic. (Khare, 2007)

The diseases that can be cured by *Datura* includes anxiety disorders, asthma, relaxes the nervous system, calm the central nervous system, inflammation, anti-epileptic, gall stone, cough, anthelmintic, whooping cough, colic, anti-convulsant, gastric catarrh, digestive ulcers, excessive urination at night, nerve problems, anti-neuralgic, Parkinson's disease, enlarges the pupil of the eye, anti-dandruff, pain, hypnotic, enteritis, disease of the eye. (URL-46)

8.5.1 Asthma

Datura is very useful in asthma, when the smoke from the burning leaves is inhaled. The leaves rolled into cigarettes can be smoked to relieve asthmatic attacks. (URL-47)

D. stramonium, used frequently as an anti-asmatic treatment. It contains a variety of alkaloids including atropine and scopolamine that can cause anticholinergic poisoning if taken in large doses. Atropine and scopolamine act on the muscarinic receptors by blocking them (particularly the M₂ receptors) on airway smooth muscle and submucosal gland cells. However, this will cause a continuous release in acetylcholine (Ach). Ach also act on nicotinic receptors; however, it is known that “over exposure” of nicotinic receptors may cause desensitization. Exposure of the foetus to *D. stramonium* when a mother uses it for asthma, will cause a continuous release of Ach, resulting in the desensitizing of nicotinic receptors, this could ultimately result in permanent damage to the foetus. (Pretorius *et al.*, 2006)

8.5.2 Epilepsy

In one experiment it is seen that about 1 week after the induction of status epilepticus in male rats by a single systemic injection of lithium (3 mEq/kg) and pilocarpine (30 g/kg), rats were continuously administered extracts of *Scutellaria lateri flora* (Skullcap), *Gelsemium sempervirens* (Gelsemium) and *D. stramonium* (Jimson Weed) displayed no seizures during treatment y, the results of this experiment strongly suggest that the appropriate combination of herbal compounds may be helpful as adjunctive interventions. (Peredery *et al.*, 2004)

8.5.3 Malaria

Datura fruit is a specific remedy for phlegmatic and bilious types of malarial fever. A desired quantity of the fruit should be placed in an earthen pot and covered with a plaster composed of cloth and clay. It should be parched in 10 to 12 grams of cowdung cakes. When the fire gets extinguished and the pot is cold, the burnt fruit should remove, powdered and kept safely in a phial for use in malarial fever.

8.5.4 Heart Disorders

The herb is valuable remedy for heart disorders. It relieves cardiac pains, distress, palpitation and aortic disorders.

8.5.5 Earache

The leaves of the herb are useful in the treatment of earache. About 125 grams each of the juice of *Datura* leaves and sesame oil should be boiled in a tin vessel on gentle fire. When half of the juice has evaporated, seven leaves of gigantic swallow wort (akh) should be put in it after smearing them with oil and sprinkling with powdered salt. The leaves should be boiled till they begin to char. This oil is then filtered through a coarse cloth and preserved in a bottle. A few drops of this oil in the ear cure earache and suppurative conditions of the ear.

8.5.6 Impotency

Datura is useful in impotency. The seeds of 15 ripe fruits should be extracted and boiled in eight kilograms of cow's milk on gentle fire. This milk should then be made into curd in the usual way and churned the next morning to extract butter which is stored in a broad-mouthed bottle. This butter, massaged every morning and evening on the penis and

the spine, will provide the desired effect. It is also used as an oral medicine. Four grains with betel leaf can be taken. The use of this butter both externally and internally in this way will gradually promote health and vigour and restore absolute fitness in the body.

8.5.7 Baldness

A preparation made from *Datura* seeds with other ingredients is useful in patchy baldness. A paste made with *Datura* seeds, liquorice, saffron and milk cream is heated in coconut oil thoroughly till the solid mass converts to a charred powder. The oil when applied on bald patches has the power to stimulate hair growth. As *Datura* is poisonous, hands should be washed thoroughly after handling the oil. The mixture should not be used on the scalp of children.

8.5.8 Problem of Breast Milk Secretion

The herb is highly beneficial in checking secretion of breast milk. In case of an unfortunate death of a newly born baby, accumulation of milk in the breasts of the mother poses a problem, causing severe pain. In such a case, warmed leaves of the *Datura* tied on the breasts will help dry the milk without any pain and difficulty. Just 2 or 3 applications will bring the desired results.

Precautions: The usual dose of *Datura* is about 2 decigrams. In large doses, it may lead to dilation of the pupils and dryness of the mouth and throat. (URL-48)

8.5.9 Dizziness

Due to presence of compounds scopolamine *Datura stramonium* is used for dizziness. It can nicely work, but it can also cause side effects such as blurred vision, dry mouth, hallucinations and heart palpitations.

8.5.10 Parkinsons' diseases

Anticholinergics present in *Datura stramonium* act as potent antiparkinsonian drugs so ayurvedic formulation containing *Datura* was found to be an effective treatment for patients with Parkinson's disease. (HP 200 Group, 1995)

8.5.11 Skin Diseases

Externally the paste of the seeds is used in urticaria and other skin diseases due to the presence of lice or other animal parasites. It is also applied to decayed teeth and to relieve

toothache. Indians apply medicated oil to the head in headache, to enlarged testis and boils and to skin in skin diseases such as pediculi, lice and psoriasis.

Dhattura juice with the root of *Boerhavia diffusa* (Satodi) and opium is used as an application for the relief of rheumatic pains and swellings over the hands and feet. In hemorrhoids, fissures and painful diseases of rectum leading to tenesmus its application as a local anodyne ointment gives relief. (Shastri, 1997)

8.5.12 Severe organophosphate (OP) poisoning

Jimson weed (*D. stramonium*) contains atropine and other anticholinergic compounds and is common and readily available. It is used recreationally for its central anticholinergic effects and is made easily into an extract by boiling the crushed seeds. The extract has rapid onset of effects and useful for treatment of OP poisoning. To determine whether pretreatment with an easily stored and prepared *Datura* seed extract (DSE) will increase survival following a severe OP poisoning, *D. stramonium* seeds were collected, crushed, and then heated in water to make a 2-mg/mL atropine solution (100 seeds contain approximately 6 mg of atropine or 0.007 mg/seed). Male rats were randomized to pretreatment with either saline (n = 10) or 7.5 mg/kg DSE (n = 10) given as a single intraperitoneal injection 5 minutes prior to a subcutaneous injection of 25 mg/kg of dichlorvos. The endpoint was time to death recorded by a blinded observer. The Kaplan-Meier estimates of the 24-hour survival rate was 90% (95% CI = 56% to 100%) for the DSE-pretreated group and 10% (95% CI = 0% to 45%) for the control group. The log-rank test revealed a statistically significant longer survival for the *Datura*-treated animals ($p = 0.0002$). Median survival time was 22 minutes 30 seconds for the control group and greater than 24 hours for the DSE-pretreated group. So pretreatment with DSE significantly increases survival following severe dichlorvos exposure. (Bania *et al.*, 2004)

8.5.13 In Bleeding Disorder

Fresh leaves of *D. stramonium* are squeezed and the juice is dropped on the affected parts in order to stop bleeding. (Govil *et al.*, 2002)

8.5.14 In insanity

Juice of *D. stramonium* leaves combined with equal quantity of centella asiatica leaves juice to alleviate insanity. (Sharma, 1996)

Plants like *Abrus precatorius* L., *Datura stramonium* L., and *Balanites aegyptiaca* L. Delile etc. commonly found in Rajasthan India show anti-HIV activity. (URL-49)

In cases general swelling of body, the whole plant is crushed and squeezed to get the juice. This juice is applied externally on the body, 2-3 times a day until care is obtained. (Govil *et al.*, 2002)

8.6 Medicinal uses of specific parts of *D. stramonium*

8.6.1 Roots and barks

A paste prepared by mixing the root bark powder of *Echinops echinatus* with the juice of *D. stramonium* and *Blumea lacera* leaves is used to avoid premature ejaculation. (URL-50)

8.6.2 Leaves

Hernandez reported that the decoction of leaves is applied to the body for fever or administered as a suppository. The fruit and leaves were considered good for pain in the chest. If too much was taken, it was believed to cause insanity. In northwestern New Spain, the Opata rubbed a leaf of *Datura* is applied on the painful area for "spleen disease". They believed it also matured tumors and abscesses. An ointment of the ground seeds and suet is rubbed on boils, pimples, and swellings; the powdered leaves are applied to hemorrhoids; and hot baths containing the plant give relief to colds and diarrhea. (URL-51)

The leaves can be used as a very powerful mind-altering drug, they contain hyoscyamine and atropine. There are also traces of scopolamine, a potent cholinergic-blocking hallucinogen, which has been used to calm schizoid patients. Atropine dilates the pupils and is used in eye surgery. The leaves have been smoked as an antispasmodic in the treatment for asthma, though this practice is extremely dangerous. (URL-52)

A teaspoonful of leaf juice is given with warm milk to expel intestinal worms particularly tapeworms. A decoction of leaf is reported to effectively control wheat rust on detached leaves. The ethanolic extract of the plant exhibited antifungal activity against rice pathogens, *Pyricularia oryzae*, *Rhizoctonia solani*, *Fusarium moniliforme* and *Curvularia lunata*. The leaf extract exhibited antifeedant and insecticidal activities against okra fruit borer, *Earias vittella* Des. Soil application of seed and leaf powder reduce the number of primary galls of *Meloidogyne incognita*. (Anonymous, 2003)

The paste of leaves along with turmeric is used externally in chest pain. (Govil *et al.*, 2002)

For treating malarial fever a leaf is taken in the morning with some sweets or uncooked grains of rice, on three days in a week (that is on Sunday, Tuesday and Saturday). (Govil *et al.*, 2002)

8.6.3 Flower

The juice of flower is useful for earache. (Govil *et al.*, 2002)

The poultice made from the flowers is applied to wounds to reduce pain. A decoction of flower and root has been used as a sedative to calm patients during setting of fractures. (Bhattacharjee, 2004)

8.6.4 Fruits

The juice of the fruit is applied to the scalp to treat dandruff and falling hair. (URL-53)

8.6.5 Seeds

The seeds are used in Tibetan medicine, they are said to have a bitter and acrid taste with a cooling and very poisonous potency. They have analgesic, anthelmintic and anti-inflammatory activity and they are used in the treatment of stomach and intestinal pain due to worm infestation, toothache and fever from inflammations. (URL-54)

8.7 Homoeopathic uses:

Main homeopathic uses of *D. stramonium* are asthma, convulsions and neuralgia (URL-46).

D. stramonium is similar to belladonna in the symptoms produced by it, and in its general physiological and therapeutic action. It has incomplete curative action in the peculiar mind affections and in convulsive ailments. It is supereminent for some spasmodic muscular movements and suppressed secretions and excretions; in such cases, absence of pain is a prominent symptom. (Joshi, 2000)

It has been homeopathically used in epilepsy as well as in other forms of spasmodic disease. It is remarkable, however, that the convulsions produced by it are partial, rather than general, affecting the arms rather than the lower extremities; affecting, also, isolated groups of muscles. Thus, twitching of the extremities and of the facial muscles, jerkings of the head, etc may be seen.

In delirium tremens, *stramonium* is indicated in the second stage too. It has been tried and with admirable success.

Stramonium has been of greatest service in suppression of the urine, without pain or discomfort, such suppression usually occurring in the course of long fevers, such as typhoid or typhus, not a simple retention of urine in the bladder; in such a case Opium would do better. Likewise in suppression of urine after miscarriage or after labor, where the desire to pass water is great but there is no ability to accomplish it, *stramonium* will

give speedy relief, provided always the case be not one of retention from a mechanical cause, such as retroversion of the uterus

In affections of the respiratory organs, *stramonium* has acquired a great reputation for the relief of asthma. The dried leaves were smoked in a pipe, sometimes alone and sometimes with niter; giving often relief but sometimes causing damage. (URL-55)

D. stramonium extracts have been used for centuries in homeopathic preparations for asthma, psychosis, epilepsy, depression, burns, wounds and Parkinson disease. Some investigators have demonstrated its antimicrobial activity in vitro. Furthermore, the plant apparently achieves palliation by means of a "narcotic" effect its resin produces. People from various cultures have treated toothaches by inhaling vapor from boiled seedpods or leaves, chewing the root, smoking the leaves and unspecified use of the flowers. (Brooks *et al.*, 2007)

8.8 Ayurvedic properties and uses:

धत्तूरो मदवर्णग्निवातकृज्ज्वर कुष्ठनुत् ।
कषाया मुधुरस्तिक्तो यूकालिक्षा विनाशनः॥
उष्णो गुरुव्रणश्लेष्मकण्डुकृमि विषापहः ।

**Dhatturo Madawarnagniwatkrijjwarkushthanut. Kashayo Madhurastikto
Yukalikshyawinashana:
Ushno Guruwarnashleshmakandukrimiwishapaha:.**

(Shastri, 1997)

Rasa-Kasaya, Madhura, Tikta (Pungent, sweet and Bitter)
Virya-Usna (Hot)
Guna-Laghu, Ruksha, Vikasi, and Vyavayi (Light, small, heavy, dry)
Vipaka- Katu (Sweat, astringent)

(Joshi, 2000)

The Malays mix leaves with wine or powdered rice and saffron and apply them externally for various pain and swellings. They heat such mixture over a torch until smoked, and then apply as a poultice over the spleen in intermittent fever. The root is powdered and applied to the gums in order to relieve the pain of tooth ache. The flowers are dried and roughly powdered with or without the leaves and rolled into cigarettes for the relief of asthma. The green fruit is powdered and applied to carbuncles in Guiana. The warmed leaves are applied topically in sciatica. In the Gold Coast, the leaves are crushed, mixed with oil and used as an antidote for poisonous insect bites, such as those of tarantula spiders.

The Xosas and Fingos use the leaf to blister the skin over inflammations where there is no open sore. The former apply the leaf for the relief of headache. Europeans apply a warmed pad of the leaf to painful and swollen parts, and a similar poultice to in growing tow-nails and to burns. In former times the fresh warmed leaf or the vapour of an infusion of the leaf was applied particularly to relieve the pain of rheumatism and gout. Europeans also make an ointment containing the juice of the leaf and young shoots for application to running sores. A poultice of the leaf was formerly applied to carcinomatous ulcers. The smokes from the burning leaves are inhaled for the relief of asthma and bronchitis. A European remedy for hemorrhoids is to steam the part over boiling water containing the leaf. The fruit juice is applied to the scalp for falling hair and dandruff. The Zulus apply the powdered leaf to bruises and wounds in both man and animals, the application being thought to draw out pus and inflammation. They use it as a smoothing application to painful wounds and sores, and the Rhodesian natives have a similar use. In southern Rhodesia, natives apply the fresh leaf to tropical ulcer. The Sutos use a decoction of the plant to bathe bruises and apply the leaf for headache. (Kritikar and Basu, 1999)

8.9 Other Uses:

D. stramonium (or *innoxia*) has been found to rapidly clear 2, 4, 6-trinitrotoluene (TNT) from munition waste sites, and to transform it via nitroreduction. Other species of *Datura* might very well have similar properties as remediators of explosives (URL-56).

Until now there is no any edible use of *D. stramonium*.

The growing plant is said to protect neighbouring plants from insects. The juice of the fruits is applied to the scalp to cure dandruff and falling hair. (URL-57) It can be used as potent weedicide also that is following graph is one of the examples of it.

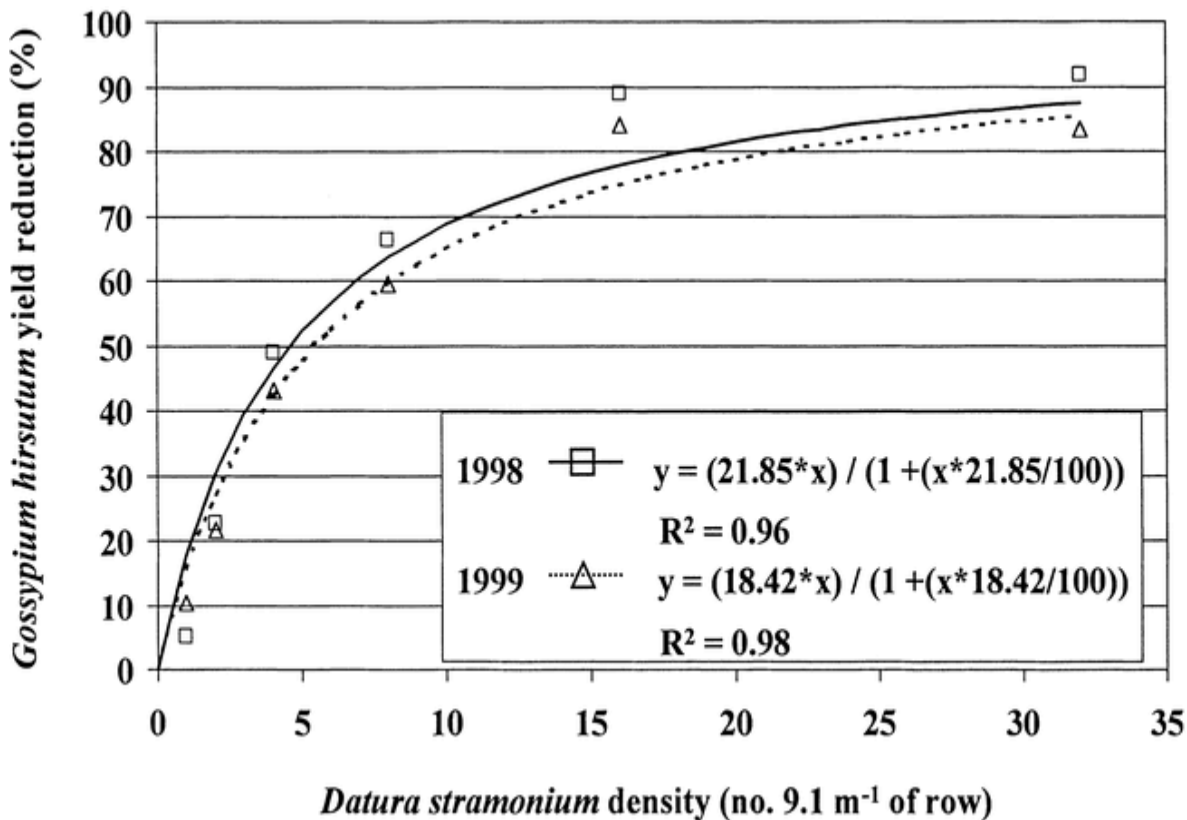


Figure- 24 Effect of *Datura stramonium* density on *Gossypium hirsutum* yield loss in 1998 and 1999. Percentage yield loss was fitted to the rectangular hyperbola equation: $y = (I \times x)/(1 + (I \times x/100))$, where y is percent yield loss, x is weed density, and I is percentage yield loss as weed density approaches zero. (URL-58)

8.10 Therapeutic Potential of *Datura*

In spite of its reputation as a witch's herb, *Datura* was commonly used for medicinal purposes even in Europe. *Datura* cigarettes have been prescribed to asthma sufferers for the anti-spasmodic/bronchodilating effect of atropine on the respiratory system.

Both atropine and scopolamine have interesting pharmacological actions. Atropine suppresses nicotinic activity (i.e., activity of agents that act to enhance the action of ACh at nicotinic receptor sites) more than cholinergic activity (i.e., activity of agents that directly mimic the actions of ACh at receptor sites or block acetyl cholinesterase). Therefore, atropine is a parasympatholytic (inhibits the physiological effects generated by stimulation of the sympathetic nervous system). It is mainly used as a mydriatic (dilate the pupils) before surgery, although a newer drug, tropocamide, is now the drug of choice due to atropine's slow degradation. Atropine is also used in the treatment of bradycardia (slow heart beat). It reduces bronchial and salivary secretions and also serves as an antidote for poisoning by organophosphate insecticides and nerves. Like atropine, scopolamine is also used as an antidote for the toxic effects of phosphate insecticides and "nerve gases." Both scopolamine/hyoscine and atropine have been used to treat motion

sickness. The mechanism is as yet unclear, but it is thought to involve inhibition of vestibular input to the CNS, thereby inhibiting the vomiting reflex.

In addition, hyoscine was formerly used together with morphine just before childbirth to produce "twilight sleep and amnesia" whereby the expectant mother remains semi-conscious but forgets the pain associated with delivery afterwards. Besides the unpleasant adverse effects of the hyoscine-morphine combination, it was also found that pain was not really reduced. The side effects included neonatal depression, drug transfer *via* the placenta to the fetus, which caused respiratory distress, teratogenesis, and in rare cases, death of the mother and/or child. Hyoscine has also been used as an anaesthetic and, more dubiously, in narcoanalysis (as a "truth drug"). In the 1950s, various intelligence agencies such as the US Central Intelligence Agency investigated the effectiveness of scopolamine as a "truth drug," but the possibility that findings could be distorted by the compound's hallucinogenic side effects resulted in the project being abandoned.

The tropane alkaloids also cause paralysis of the muscles of light accommodation (cycloplegia) and pupil dilation (mydriasis).

One of the first medical investigations to uncover the therapeutic potential of *Datura* in mental health was undertaken in 1762 by Anton Stock. His investigations led him to report that *Datura* had the ability to make "unsound minds sane and sane minds mad." In 1886, August Sohrt of Torty is said to have utilized *Datura* isolates for the "mentally ill," possibly on the recommendation of one of his teachers who claimed that hyoscine was an extremely valuable medicine for psychiatric treatment. It has been suggested that the period following the comatose state induced by *Datura* may be ideal for psychotherapeutic efforts, comparable with the teaching of "moral values" by the Chumash tribe after inebriation. However, it has been shown that small doses of some *Datura* constituents such as atropine may impair learning and memory functions in dementia. (URL-59)

9. TOXICOLOGY

Datura poisoning is common in India, the seeds being usually employed; a few cases of poisoning by the leaves and root have, however, been reported. In the great majority of cases the motive for its administration is facilitation of theft, and when in India an individual has been first drugged and then robbed, it will usually be found that *Datura* has been employed. A common form of theft by aid of this poison is road robbery, and D. W. Center mentions the use in such cases of a hollow pestle, the cavity containing the seeds. Inversion of this while pounding the masaleh or spices always used in Indian cookery, introduces the poison into the food without existing suspicion. It rarely happens that there is any ground for suspecting homicidal intent cases of *Datura* poisoning; in fact, there seems to be a popular belief in this country that the drug is simply an intoxicant. As Harvey remarks, road poisoners sometimes partake with their victims of the drugged food, which they would hardly do if aware of the danger. Commonly, when *Datura* is used for criminal purposes in India, the poison is mixed with sweetmeats on food, but in exceptional cases it has been mixed with tobacco given to the victim to smoke. *Datura* is said to be used by vendors of native liquor, for the purpose of increasing its intoxicating

power, the liquor being poured into a vessel which has been first filled with the smoke of the burning seeds. Suicidal poisoning by *Datura*, if it occurs at all, is extremely rare. Accidental poisoning among children are occasionally met with. (Govil *et al.*, 2002)

Many of the cases of *Datura* intoxication reported in the 1960s and 1970s occurred in hospitals and often featured quite severe symptoms. These cases may have involved people ingesting large (potentially toxic) amounts of the alkaloids with virtually little knowledge of the potential effects and dosages.

Symptoms such as increased heart rate, drying up of the mucous membranes, dry throat and cramps, restlessness, giddiness, disorientation, constipation, and confusion have been observed. Uncontrolled talking or laughing, memory disturbances, and repetitive acts, as well as hallucinations and elated fantasies are also common features. These effects are often followed by a deep prolonged sleep during which sexually inclined dreams and hallucinations can be experienced. On "recovery" from this state of altered consciousness, a characteristic "hang over" and amnesia are felt.

In 1968, DiGiacomo reported the symptoms presented in Table 12 as having occurred in four cases of *Datura* intoxication in teenagers.

Table 12:- Central and peripheral effects of anticholinergic syndrome induced by *D. stramonium* intoxication in 4 cases

Central nervous system effects (begins 30-60 minutes after ingestion)	Peripheral effects
Confusion, Disorientation, Ataxia slurred speech, Fluctuating lucidity and hyperactive agitated state, Staring into space, Labile state (of laughter and crying), Sensitivity to peripheral activity, Misidentification of people, Auditory hallucinations (voices of close friends), Visual hallucinations (beetles or insects)	Red appearance, Warm, dry skin and mucous membranes, Dysphasia (due to mucosal dryness), Elevated body temperature (for 8 to 12 hours), Tachycardia (in 3 patients), Pupillary dilation with poor reaction to light, Blurred vision

In Table 13, Gowdy provides a more representative picture in a review of 212 cases of *D. stramonium* intoxication (mentioning both seed pod and ingestion of asthma powder containing dried *Datura*).

Table 13:- Symptoms of *D. stramonium* intoxication in 212 cases

Symptom	No. of people
Hallucinations	99
Disorientation	45
Dilated pupils	36
Dryness of skin and mucous membranes	32
Ataxia	31
Hyperactivity or combativeness	29
Amnesia	21
Fever	20
Rapid pulse	18
Flush	13
Paranoia	10
Anxiety	8
Blood pressure elevated	2

In his review, Gowdy points out that 99 out of the 212 cases actually experienced hallucination. Since this was the expressed intention by most of the inebriated, nearly half achieved what they had set out to do and only a reported 8 out of 212 experienced anxiety. Gowdy also states that negative or biased reporting of symptoms and the omission of positive effects or terminology could be because reports of amnesia, anxiety, and paranoia would inevitably discourage abuse of these preparations.

In some of these cases, behavior comparable to that of "possession inebriation" was described here as "violent" or "aggressive" (Table 2 describes as hyperactivity or combativeness). Similarly, what might be deemed "hallucination" in orthodox medical terms may in another context be referred to as a "vision?"

Although the outcome of *Datura* intoxication is said to be favorable and "treatment" best confined to protective measures, prolonged use of scopolamine may result in withdrawal symptoms including dizziness, nausea, vomiting, headache, and disorientation. (URL-60)

Experimental work reported here, indicates an intake of *D. stramonium* seeds equivalent to a dose of about 1.5 mg alkaloid per kg body-weight as a threshold level for the expression of mild toxicity symptoms in the pig. The pig can very effectively reject whole seeds in the diet and whole seeds ingested may pass through the gut intact. Thorn apple seems far less likely to cause poisoning in the housed pig than is generally believed. The standard text misquotes the findings of earlier work by a factor of 250. (URL-61).

The toxic effects of *D. stramonium* most often include visual and auditory hallucinations, confusion and agitation. Severe and even fatal complications (coma, respiratory distress or death in more than 5% of cases) are not rare since the lethal concentration of the drug's toxic substances (i.e., atropine and scopolamine) is close to the level at which delirium occurs. Let's see the following cases:

CASES: A 17-year-old man was admitted to the emergency department with agitation, delirium with persecutory ideation and frightening hallucinations of being assaulted by animals. Blood samples taken 12 hours after *D. stramonium* ingestion and analyzed with liquid chromatography and mass spectrometry (LC-MS/MS) found 1.7 ng/mL of atropine, close to the lethal level. After restraint and treatment with the antipsychotic drug cyamemazine, the young man returned to normal 36 hours after drug ingestion. A 17-year-old woman was admitted to the emergency department after losing consciousness on a public thoroughfare. At the emergency department, 2 hours after she had ingested *D. stramonium*, she was agitated, with delirium, anxiety, and frightening visual and tactile hallucination of green turtles walking on her as well as auditory hallucinations. Blood samples at D0, D1 and D2 after *D. stramonium* ingestion, analyzed with LC-MS/MS, found: 1.4, 1.0, and 0.2 ng/mL of scopolamine, respectively. Atropine was massively eliminated in urine on D1 (114 ng/mL). After restraint and cyamemazine treatment, the young woman returned to normal 40 hours after she had first ingested this hallucinogen.

DISCUSSION: These cases of intoxication with *D. stramonium* are, the first clinical reports correlated with toxicologic analysis by the reference method (LC-MS/MS) in an emergency setting. Since neither the drug-users nor those accompanying them usually volunteer information about drug use, it is important to consider this specific risk in cases of agitation and confusion in adolescents or young adults. (URL-62)

D. stramonium is a hallucinogenic plant that causes serious poisoning. Consumption of any part of the plant may result in a severe anticholinergic reaction that may lead to toxicity and occasionally cause diagnostic difficulties. It is reported that patients with coma as a presenting sign of intoxication following intentional *Datura* seed tea ingestion. (Diker *et al.*, 2007)

9.1 Clinical effects of *D. stramonium* poisoning:

The mnemonic for clinical effects of typical *Datura* poisoning is: "blind as a bat, mad as a hatter, red as a beet, hot as a hare, dry as a bone, the bowel and bladder lose their tone, and the heart runs alone." Symptoms include mydriasis; cycloplegia; flushed, warm, dry skin; dry mouth; ileum; urinary retention; tachycardia; hyper or hypotension; delirium with hallucinations; jerky, myoclonic movements; choreoathetosis; hyperthermia; coma; respiratory arrest; rare seizures; and central stimulation followed by depression. Hallucinations are reported in as many as 83% of cases; typically they are simple visual images in natural colors, but infrequently also tactile hallucinations of crawling insects.

The onset of symptoms occurs within 30 to 60 minutes after smoking leaves or drinking tea; and 1 to 4 hours after ingestion of plant material or seeds. Initial symptoms include dry mouth then pupil dilatation. The duration of symptoms is often 24 to 48 hours because of delayed gastrointestinal motility; symptoms have been reported to last up to 1 to 2 weeks. Although poisoning may lead to fatal modularly paralysis, arrhythmias and cardiovascular collapse, Jimson Weed-related deaths mainly are as a result of impaired judgment and coordination resulting in risk-taking activities associated with accidental

death.

The differential diagnosis of Jimson Weed poisoning includes any other medicines with anticholinergic properties such as: antihistamines, antispasmodic GI preparations, over-the-counter sleep aids, cold preparations, muscle relaxants, antipsychotics, other plants, mushrooms, scopolamine, or cyclic antidepressants.

9.2 Management of *D. stramonium* poisoning:

Management of Jimson Weed poisoning is generally conservative beginning with the usual ABC's (that is airway, breathing and circulation) of resuscitation. If the patient presents with stupor or coma, treatment may include dextrose, thiamine, naloxone, etc. Otherwise the main component of management is support and observation. The patient should be placed in a nonstimulating environment and monitored with frequent vital signs. A cooling blanket can be used for hyperthermia. The patient may require bladder catheterization for urinary retention.

Decontamination should be considered even hours after ingestion secondary to the anticholinergic properties which may delay the gastric emptying and absorption of the vegetable matter. Lavage has been proposed up to 48 hours after ingestion secondary to delayed gastric emptying. Activated charcoal is an effective alternative to lavage in preventing further drug absorption and should be given with a cathartic if no ileus is present. Multidose activated charcoal and hemodialysis are not considered effective, although Haddad has speculated that multidose activated charcoal may decrease continued, delayed absorption secondary to the decreased GI motility. Hemodialysis and forced diuresis do not enhance the elimination of atropine.

Physostigmine works by reversible inhibition of acetylcholinesterase, the enzyme that degrades acetylcholine. This increases the concentration of acetylcholine which causes the stimulation of muscarinic and nicotinic receptors. The tertiary amine structure allows penetration of the blood-brain barrier to allow exertion of a central cholinergic effect. Cholinergic stimulation of the brainstem reticular activating system causes nonspecific analeptic arousal effects. However physostigmine's use may precipitate seizures, cholinergic crisis, bradyarrhythmias and asystole. Relative contraindications include: history of cardiovascular disease, gangrene, asthma, glaucoma, and GI/GU obstruction. Thus its use as a cholinergic agent in Jimson Weed poisoning is controversial and is generally reserved for life-threatening, intractable, anticholinergic effects including hypertension, seizures, unstable tachycardia, hyperthermia, or pronounced hallucinations unresponsive to other agents. The dose is 0.5 mg every 5 minutes as needed in a child to a maximum total of 2 mg; 2 mg in an adult slow IV injection, or 0.02 mg/kg repeated every 20 to 30 minutes. Onset of action is within 3-8 minutes, duration is 30-60 minutes, and elimination half-life is 15 to 40 minutes. Atropine (0.5 mg/1 mg physostigmine given in the last dose) should be available for reversal of symptoms of cholinergic excess from the physostigmine that are bradycardia, heart block, or excessive secretions. Shenoy described the use of physostigmine as a diagnostic tool with a hallucinating

patient who became worse on haloperidol. He was given 2 mg of physostigmine as a challenge, and became lucid enough to give the history of the ingestion, then was treated with lorazepam. Guharoy suggested its use in treating mild symptoms in three teens, who were discharged without problems in 24 hours. Rodgers proposed conservative treatment after reviewing 29 cases over 7 years that received no physostigmine. He felt that charcoal, sedatives and monitoring were adequate and that the majority of ingestions pose little threat.

Alternatives or adjuncts to using physostigmine to treat tachyarrhythmias are alkalization of the blood to pH 7.5 and propranolol. The dosing of propranolol for an adult is 2 mg IV over 1 minute, repeating every 2-5 minutes to a maximum of 5mg total. For children 0.01-0.1 mg/kg/dose over 10 minutes, maximum 1 mg/dose. For patients that require sedation for extreme agitation, benzodiazepines or hydroxyzine should be used instead of phenobarbital, phenothiazines, or haloperidol secondary to their additive anticholinergic effects. A patient should be admitted if physostigmine is needed or until CNS symptoms resolve.

9.3 Prevention:

Defoliation programs are one way to decrease access to Jimson Weed. It is important to educate health care providers about the hazards and symptoms involved with contact with *D. stramonium*. However information to the public should stress hazards and avoid explicit descriptions and locations of the plant which might encourage some to purposefully seek out Jimson Weed for its use as a recreational drug. (Arnett, 1995; URL-63)

The toxic effect of *D. stramonium* was studied in the Horses. The clinical signs manifested after intoxication with Jimson weed were: hyperthermia, tachycardia, polypnoea with dyspnoea, acute gastric dilatation, secondary intestinal gas accumulation, mydriasis, dry mucosae, complete refusal of feed, and lack of thirst, defecation and urination. In lactating mares, the course of Jimson weed intoxication was more rapid, without the typical signs. The suckling foals did not manifest signs of intoxication. The prognosis is more favourable, if during the recovery from intoxication polydipsia, polyuria and frequent defecation are observed. The pathomorphological studies showed a toxic liver dystrophy and extensive dystrophic and necrotic changes in the kidneys and myocardium.

Table 14:- Change in clinical indices in horses after intoxication with Jimson Weed (*D. stramonium*) (I- horses with typical clinical signs: 9 stallions, 1 gelding, 8 mares, and 3 of them pregnant. II- horses with less obvious signs of intoxication: 3 stallions, 3 geldings, 2 pregnant mares, 8 lactating dams group) and controls (III group).

Indices	Groups	Days after the intoxication						
		1 st	2 nd	3 rd	4 th	5 th	6 th	7 th
Body temperature (C°)	I	38.8±0.3 ^c	38.6±0.2 ^c	37.9±0.1	38.0±0.2	37.6±0.3	37.9±0.3	37.5±0.2
	II	37.8±0.2 ^b	37.4±0.1	37.4±0.1	37.6±0.2	37.8±0.2	37.2±0.2	37.4±0.3
	III	37.5±0.2	37.2±0.1	37.9±0.2	37.7±0.3	37.3±0.2	37.5±0.2	37.4±0.2
Heart rate (min ⁻¹)	I	98.8±8.3 ^c	72.4±5.4 ^c	54.5±6.3	41.3±5.8	50.2±6.3	43.0±5.0	38.7±4.2
	II	65.4±7.1 ^b	58.3±6.7 ^a	48.3±6.2	38.8±6.3	48.4±4.2	46.6±5.8	42.3±3.3
	III	37.8±5.8	39.1±4.8	40.2±7.1	38.8±5.5	42.4±4.8	37.8±5.2	35.0±5.0
Respiratory rate (min ⁻¹)	I	64.5±7.3 ^c	34.2±5.8 ^b	15.8±2.6	14.5±2.6	12.7±1.8	14.4±2.9	13.2±2.6
	II	30.2±5.6	16.2±2.8	18.2±2.1	13.7±1.4	14.4±2.3	12.7±1.8	13.4±1.1
	III	16.2±2.3	14.3±2.4	16.8±1.4	15.6±2.3	14.8±1.8	13.8±2.1	15.2±2.7

^a $p < 0.05$; ^b $p < 0.01$; ^c $p < 0.001$.

(Binev *et al.*, 2006)

10. PHARMACOLOGICAL ACTIONS

In large doses, stramonium is an energetic, narcotic poison, producing dryness of the throat, thirst, nausea, giddiness, nervous agitation, dilatation of the pupil, obscurity of vision, headache, disturbance of the cerebral functions, perspiration, occasional relaxation of the bowels, and, in some cases diuresis. When about to prove fatal, maniacal delirium, loss of voice, dryness of throat, etc., are usually present. In fact, the physiological action of stramonium is practically the same as that of belladonna, though it is thought to influence the sympathetic more strongly, to occasion irregular heart-action, and induce greater delirium. Full doses of it are said to increase the sexual appetite and power. Daturine, though chemically similar to atropine, produces a more profound effect, both as a mydriatic and in other ways, and is more liable to produce depression, heart failure, and unconsciousness.

Daturine is seldom employed in medicine. It is a very energetic poison, 1/8 grain having killed a sparrow in 3 hours, and nearly proved fatal to a cat, when applied to the eye. Very minute quantities applied to the eye occasion protracted and excessive dilatation of the pupil. In cases of poisoning by *D. stramonium* and its alkaloid, the best mode of obtaining relief is to evacuate the stomach by emetics or the stomach-pump, after which vinegar and water may be used, with mucilaginous drinks, at a later period, and strong

coffee, tea, and other stimulating drinks, if there is much prostration. The physiological antidote is opium (or morphine) its employment being guided by the degree of pupillary contraction produced. Electricity and pilocarpine may also be useful. According to Garrod, caustic alkalies, but not their carbonates, destroy the active principle of stramonium.

In medicinal doses, stramonium acts as an anodyne antispasmodic, without causing constipation, and will prove serviceable in cases where opium can not be given. It does not readily produce sleep, but if sleep follows, it is generally due to the alleviation of pain or nervous irritability produced by the drug. Belladonna has proved serviceable in *gastritis* and *enteritis*, and may likewise be used to allay *neuralgic pains*. It is very remarkable that a plant so closely allied to belladonna in physiological action, should be so different in some of its therapeutic effects, and particularly in regard to pain. For deep-seated pain, as of *neuralgia*, etc., it is far less effective than belladonna, but for *superficial neuralgia*, when locally applied, it is more effective than that drug. It well illustrates the fallacy of prescribing remedies for certain effects, because of known physiological action of a drug; the therapeutical effects often being widely at variance. Again, it is more effective in mental disorders than is belladonna. Besides, while daturine, in some respects, exceeds atropine in power, in many respects it does not in the least accomplish the therapeutical results of the latter. Stramonium, in combination with quinine, forms an invaluable preparation which has been found beneficial in *intermittent fever*, *periodic pains*, *headache*, *dysmenorrhoea*, *delirium tremens*, etc. It is said that the seeds exert an influence to prevent abortion.

While less effective than belladonna for the relief of pain, it may be employed in *neuralgic dysmenorrhoea*, with nervous irritation, *tic-douloureux*, *spasmodic intestinal pain*, *sciatica*, *rheumatism*, and *syphilitic pain*. It is a minor remedy for some forms of *epilepsy*. It has been lauded for *vertigo* and *headache*, from disordered conditions of the stomach produced by hyperacidity, and is also endorsed for *muscular tremblings* of the hands of functional or reflex origin, and associated with great restlessness. When *gastric headache* is accompanied with marked nervous erethism and unsteadiness, its action is specific.

D. stramonium is a remedy of value in troubles resulting from *cerebral irritation*, in abdominal derangements, when due to irritation of the sympathetic. It has long borne a reputation as a remedy for *acute delirium*, and in *acute mania*, the patient being violent, boisterous, angry, and possessed of a destructive tendency. Such delirium may occur as a grave symptom in inflammatory and febrile diseases, particularly in *zymotic diseases*. The dose here ranges from a fraction of a drop to 4 drops of specific stramonium. In regard to its action in maniacal excitement and other nervous disorders, Dr. Scudder says: "It may be given in acute diseases when the patient is *furiously delirious*; in *delirium tremens*, when the patient is enraged and inclined to injure those present, destroy furniture, or harm himself; in *violent mania*; in *epilepsy*, associated with or followed by maniacal excitement. In chronic disease, it is enough that the patient feels inclined to violent outbursts of passion, and has difficulty in restraining himself." It is often a remedy of value in *hysterical mania*, with convulsions, and alternate laughing and

weeping, and for *globus hystericus*. With these conditions, there is usually headache, flushed face, and sexual irritation. Prof. Locke speaks of it as a good remedy in some forms of *paralysis* following convulsions, strong injections, or shock, or due to suppressed eruptions. Bloating and redness of the face indicate it. For *retrocession of the eruptions* in the *exanthemata*, it is of considerable value, though less efficient than belladonna. As an antidote to the *opium habit*, stramonium may be given. Stramonium is indicated in *cough*, with constriction and difficult deglutition and impaired innervation. It gives temporary relief in purely *spasmodic asthma*, but usually fails when dyspnoea or asthmatic breathing are due to pulmonary or cardiac diseases. As a remedy for asthma it was introduced into England, in 1802, by General Gent, who brought the custom from India, where the smoking of *Datura*, under the name *gharbhah* ("forgetfulness of home"), was common. It soon became very fashionable for individuals having difficult breathing to smoke *gharbhah*. For spasmodic asthma, the remedy may be given internally, that is powdered stramonium leaves; powdered anise seeds, powdered potassium nitrate are mixed without trituration. Then the mixture is burned, a thimbleful of this powder under a conical vessel, as a funnel, and inhale the fumes. Or equal amounts of sage and stramonium leaves may be smoked in a pipe until slight nausea is induced. It is useful in severe paroxysms of *whooping-cough*, with hemorrhage from the mouth and nose, and in *haemoptysis*, brought on by fits of coughing, or by spasm. It is a better cough remedy than opium, as it does not arrest the secretions. Stramonium has been extolled for its effects in *milk-sickness*. In plethoric habits, and in patients with determination to the head, the larger doses of stramonium must be administered with caution, keeping the excretory organs, as the skin, kidneys, and bowels, in an active condition during its employment.

Externally, a poultice of the fresh leaves, bruised, or the dried leaves in hot water, will be found an excellent application over the bowels, in severe forms of *gastritis*, *enteritis*, *peritonitis*, *acute rheumatism*, *painful bladder affections*, *pleurisy*, etc. "I have in many instances applied the leaves to the perineum, in cases of *retention of urine* from enlarged prostate, where it was impossible to introduce a catheter, and, after having allowed them to remain for about 1/2 hour, have been enabled to pass the catheter with ease and facility, and thus afford relief to the patient. It will also be found beneficial as a local medication to all species of *painful ulcers*, *acute ophthalmia*, taking care not to produce too great mydriasis, *swelled breasts*, *orchitis*, *parotitis*, and other *glandular vulvar inflammation*, *inflammatory rheumatism*, and *irritable hemorrhoidal tumors*. An ointment of it is very valuable in many of the above diseases, but it should be prepared carefully without too great heat, from fresh leaves and stems, if possible. In cases where the leaves can not be obtained, a plaster of the alcoholic extract or inspissated juice may be applied over the affected parts, or the extract may be rendered thin by heating it in diluted alcohol, and then forming into a poultice with meal or moistened bread and applied. The ointment is exceedingly efficient in *cutaneous hypertrophy around the anus*, attended with great itching, and sometimes with sero-purulent secretion. Dose of the powdered leaves or seeds, from 1/10 to 5 grains; of the extract, which is the best form of administration, from 1/20 to 2 grains; of the tincture, for which the seeds, bruised, are preferable, from a fraction of a drop to 30 drops; specific stramonium 1/20 to 10 minims.

(URL-64)

10.1 Antibacterial effect of *D. stramonium*:

The antibacterial activity of the methanol extracts of the aerial parts of the *D. stramonium* was investigated. The extracts showed activity against Gram positive bacteria in a dose dependent manner. Little or no antibacterial activity was found against *Escherichia coli* and *Pseudomonas aeruginosa*. (Eftekhar *et al.*, 2005)

A lectin, *D. stramonium* agglutinin, induced irreversible differentiation in C6 glioma cells. The differentiated cells had long processes, a low rate of proliferation and a high content of glial fibrillary acidic protein. When the medium was replaced with *D. stramonium* agglutinin-free medium after 1 h, cell proliferation continued to be inhibited. Experiments with several other lectins indicated that both recognition of linear N-acetyllactosamine repeats and recognition of multiantennary units of cell-surface glycans were required for the inhibition of C6 proliferation. Proliferation of four human glial tumour cells was also inhibited by *D. stramonium* agglutinin. Further, these differentiated human glial tumour cells had long processes and a high content of glial fibrillary acidic protein similar to differentiated C6 glioma cells. Taken together, these observations suggest that *D. stramonium* agglutinin may be useful as a new therapy for treating glioma without side effects. (Sasaki *et al.*, 2002)

11. PREPARATION AND USES

11.1 Preparations:

11.1.1 Extractum Stramonii. Extract of Stramonium

Manufacture

PILULAR, macerate, percolate 100g with 75 p.c. alcohol until exhausted, reclaim alcohol, evaporate residue at 70 °C (158 °F) to pilular consistence, frequently stirring, mix thoroughly; after assay add enough glucose for extract to contain 1 p.c. of total alkaloids, mix thoroughly.

POWDERED, macerate, percolate 100g with alcohol, reserve first 100 cc. and continue until exhausted (100 cc); reclaim alcohol from second percolate until residue in still is 10 cc., to which add first reserve and distill until residue of syrupy consistence; transfer to a dish, rinse still with little warm alcohol, which add to dish and evaporate at 70 °C (158 °F) to soft extract, frequently stirring, add dried starch 5 g, heat, with stirring, until nearly dry, thoroughly incorporate dried starch 2g, expose to current of warm air until dry, pulverize; after assay add enough dried starch for extract to contain 1 p.c. of total alkaloids, mix thoroughly, pass through fine sieve; contains 0.9-1.1 to 1 p.c. of the alkaloids; 1g represents 4g of the drug. Should be kept in small, wide-mouthed, tightly-stoppered bottles. Dose, grain 1/6-1/2 (0.01-01.03 g).

11.1.2 Unguentum Stramonii, N.F.

Pilular extract. 10 p.c., hydrous wool fat 20, benzoinated lard 65, diluted alcohol 5.

11.1.3. Tinctura Stramonii.

Tincture of Stramonium;

Manufacture: 10 p.c. Similar to Tinctura Veratri Viridis, page 104; menstruum: diluted alcohol--percolate 95 cc., assay, and add enough menstruum for the 100 cc. to contain 0.0225 to 0.0275 Gm. of total alkaloids. Dose, 0.3-2 cc.

11.1.4. Fluidextractum Stramonii, N.F.

Fluid extract of stramonium (80 p.c. alcohol). Dose 0.06-.3 cc.

11.2 Unofficial preparation: Plaster, Juice (Succus Stramonii), Cigarettes, Fomentation.

Properties

Narcotic, anodyne, antispasmodic, diuretic, mydriatic. Internally very similar but stronger than belladonna; weaker externally. Large doses produce dry throat, cardiac irregularity, high fever with delirium, increase sexual desire, possibly laughing and hallucinations (like in cholera, alcoholism), dizziness, fainting, red eruptions, dilated pupils, insomnia, black objects appear green; pneumogastric becomes paralyzed, thus stopping the inhibitory action, hence whole system paralyzed finally by over-stimulation, including the heart, then delirium, stupor, convulsions, death by asphyxia; in case of recovery remember nothing that has occurred; does not affect some animals, as caterpillar, tribe, goats, etc.

Insanity, mania, melancholia, epilepsy, nervous asthma (grains 15 (1g) of leaves smoked with tobacco or sage at each paroxysm), whooping- cough, dysmenorrhea, retention of urine, hepatic colic, laryngeal cough, chorea. Ointment in ulcers, hemorrhoids, fissures, skin diseases, poison-ivy eruptions, rheumatism, bruises, sprains. In the absence of belladonna may use stramonium with good results. (URL-65)

Dosage-

Leaf 60-185 mg powder; seed 60-120 mg power. (Khare, 2007)

12 RESEARCH UPDATE IN *D. STRAMONIUM*

Several researches (more than thousands till the date) have been conducted in plant *D. stramonium* but many of them are related with genetic variation, tissue culture, poisoning and anticholinergic effect of the plant. Some of the research titles are mentioned here.

1. Hyoscyamine biosynthesis in *D. stramonium* hairy root in vitro systems with different ploidy levels.
2. Unilateral mydriasis due to Angel's trumpet.
3. Intentional *D. stramonium* intoxication and circumstances of use in two adolescents
4. Toxicity studies on *D. metel* L. with reference to official stramonium.
5. Coma as a presenting sign of *D. stramonium* seed tea poisoning.
6. Acute *D. stramonium* poisoning in an emergency department.
7. Food poisoning due to Jimson weed mimicking *Bacillus cereus* food intoxication in Austria, 2006.
8. *D. stramonium* poisoning - a new problem in children and young people's toxicomania in Poland.
9. Clinical and pathological studies on intoxication in horses from freshly cut Jimson weed (*D. stramonium*) contaminated maize intended for ensiling.
10. The production of gastrodin through biotransformation of p-hydroxybenzaldehyde by cell suspension culture of *D. stramonium*.
11. Studies on some para-clinical indices on intoxication in horses from freshly cut Jimson weed (*D. stramonium*)-contaminated maize intended for ensiling.
12. Toxicological analysis of a case of *D. stramonium* poisoning
13. Colorimetric activity measurement of a recombinant putrescine N-methyltransferase from *D. stramonium*.
14. Functional properties of prosomal protein 39 kappaDa from *D. stramonium* leaves infected with Potato Virus X.
15. Alkaloid patterns in some varieties of *D. stramonium*.
16. Regionally specific distribution of the binding of anti-glutamine synthetase and anti-S100 antibodies and of *D. stramonium* lectin in glial domains of the optic lobe of the giant prawn.
17. Jimsonweed poisoning and the anticholinergic syndrome
18. Expression of an antisense *D. stramonium* S-adenosylmethionine decarboxylase cDNA in tobacco: changes in enzyme activity, putrescine-spermidine ratio, rhizogenic potential, and response to methyl jasmonate.
19. Antimicrobial activity of *Datura innoxia* and *D. stramonium*.
20. Comparison of the nucleotide sequences of ferredoxin-cDNAs among some *Datura* plants.
21. Analysis of biologically active compounds in potatoes (*Solanum tuberosum*), tomatoes (*Lycopersicon esculentum*), and jimson weed (*D. stramonium*) seeds.
22. TMV-infection localization and development of induced virus resistance in *Nicotiana sanderae* Hort., *D. stramonium* L. and *D. metel*.
23. Herbal treatment following post-seizure induction in rat by lithium pilocarpine: *Scutellaria lateriflora* (Skullcap), *Gelsemium sempervirens* (Gelsemium) and *D. stramonium* (Jimson Weed) may prevent development of spontaneous seizures.
24. Population variation in the cost and benefit of tolerance and resistance against herbivory in *D. stramonium*.
25. Accidental familiar poisoning by *D. stramonium*.
26. Fatal poisoning from ingestion of *D. stramonium* seeds.

27. Altered nitrogen metabolism associated with de-differentiated suspension cultures derived from root cultures of *D. stramonium* studied by heteronuclear multiple bond coherence (HMBC) NMR spectroscopy.
28. Jimson weed extract as a protective agent in severe organophosphate toxicity.
29. Neurological findings in a case of coma secondary to *D. stramonium* poisoning.
30. Evolutionary ecology of *D. stramonium*: equal plant fitness benefits of growth and resistance against herbivory.
31. Voluntary poisoning by ingestion of *D. stramonium*. Another cause of hospitalization in youth seeking strong sensations
32. Effect of physostigmine and gastric lavage in a *D. stramonium*-induced anticholinergic poisoning epidemic.
33. Alkaloid spectrum in diploid and tetraploid hairy root cultures of *D. stramonium*.
34. Pathological alterations in the ovaries of *Culex pipiens* induced by fixed oil extracts from *Thevetia peruvine*, *D. stramonium* and *Acacia* sp.
35. Anther-stigma separation is associated with inbreeding depression in *D. stramonium*, a predominantly self-fertilizing annual.
36. Prostaglandin D₂ generation by rat peritoneal mast cells stimulated with *D. stramonium* agglutinin and its inhibition by haptenic sugar and wheat germ agglutinin.
37. Inhibition of proliferation and induction of differentiation of glioma cells with *D. stramonium* agglutinin.
38. Biosynthetic studies on the tropane alkaloid hyoscyamine in *D. stramonium*; hyoscyamine is stable to in vivo oxidation and is not derived from littorine via a vicinal interchange process.
39. Coma with focal neurological signs caused by *D. stramonium* intoxication in a young man.
40. GC-MS investigation of tropane alkaloids in *D. stramonium*.
41. *D. stramonium* mass poisoning in Botswana.
42. 4-Hydroxycinnamoyl-CoA hydratase/lyase, an enzyme of phenylpropanoid cleavage from *Pseudomonas*, causes formation of C(6)-C(1) acid and alcohol glucose conjugates when expressed in hairy roots of *D. stramonium* L.
43. Metabolism of the herbicide glufosinate-ammonium in plant cell cultures of transgenic (rhizomania-resistant) and non-transgenic sugarbeet (*Beta vulgaris*), carrot (*Daucus carota*), purple foxglove (*Digitalis purpurea*) and thorn apple (*D. stramonium*).
44. D-galactose-specific sea urchin lectin sugar-specifically inhibited histamine release induced by *D. stramonium* agglutinin: differences between sugar-specific effects of sea urchin lectin and those of D-galactose- or L-fucose-specific plant lectins.
45. Evolutionary ecology of the tropane alkaloids of *D. stramonium* L. (Solanaceae).
46. Heritability of stigma position and the effect of stigma-anther separation on outcrossing in a predominantly self-fertilizing weed, *D. stramonium* (Solanaceae).
47. Crystallization and preliminary crystallographic study of tropinone reductase II from *D. stramonium*.
48. The complex-type oligosaccharide binding lectin *D. stramonium* agglutinin detects type II A muscle fibres in the branchial biceps from man and cat.

49. Molecular cloning and functional identification of a plant ornithine decarboxylase cDNA.
50. An alternative medicine treatment for Parkinson's disease: results of a multicenter clinical trial. HP-200 in Parkinson's Disease Study Group.
51. Growth and the uptake of sucrose and mineral ions by transformed root cultures of *D. stramonium*, *Candida xaurea*, *D. wrightii*, *Hyoscyamus muticus* and *Atropa belladonna*.
52. *D. stramonium* poisoning. Identification of tropane alkaloids in urine by gas chromatography-mass spectrometry.
53. An initial signal of activation of rat peritoneal mast cells stimulated by *D. stramonium* agglutinin: a confocal fluorescence microscopic analysis of intracellular calcium ion and cytoskeletal assembly.
54. *D. stramonium* agglutinin released histamine from rat peritoneal mast cells that was inhibited by pertussis toxin, haptenic sugar and N-acetylglucosamine-specific lectins: involvement of glycoproteins with N-acetylglucosamine residues.
55. The reduction of tropinone in *D. stramonium* root cultures by two specific reductases.
56. Protein chemotaxonomy of genus *Datura*: identical amino acid sequence of ferredoxin from two varieties of *D. stramonium*.
57. Jimson weed toxicity: management
58. Atropine poisoning after eating chapattis contaminated with *D. stramonium* (thorn apple).
59. Febrile coma with granulocytosis caused by *D. stramonium* poisoning.
60. The formation of 3 alpha- and 3 beta-acetoxytropanes by *D. stramonium* transformed root cultures involves two acetyl-CoA-dependent acyltransferases.
61. The effects of low levels of dietary toxic weed seeds (jimson weed, *D. stramonium* and sicklepod, *Cassia obtusifolia*) on the relative size of rat liver and levels and function of cytochrome P-450.
62. *D. stramonium* agglutinin-reactive alpha-fetoprotein isoforms in hepatocellular carcinoma and other tumors.
63. Production of hyoscyamine by 'hairy root' cultures of *D. stramonium*.
64. Carbohydrate binding properties of complex-type oligosaccharides on immobilized *D. stramonium* lectin.
65. Attempted suicide by ingestion of *D. stramonium* seeds
66. Partial purification and properties of tropine dehydrogenase from root cultures of *D. stramonium*.
67. Structural studies of the carbohydrate moieties of lectins from potato (*Solanum tuberosum*) tubers and thorn-apple (*D. stramonium*) seeds.
68. Chromosomal characteristics and occurrence of main alkaloids in *D. stramonium* and *D. wrightii*.
69. Acute atropinic syndrome caused by abuse of anti-asthmatic cigarettes (*D. stramonium*)
70. Tissue and subcellular distribution of the lectin from *D. stramonium* (thorn apple).
71. Ultrastructural features of the parenchyma of young leaves of *D. stramonium* L. systemically infected with potato virus X.
72. Bronchodilator effects of antiasthmatic cigarette smoke (*D. stramonium*).

73. A RNA extract from oncogenic and non oncogenic strains of *Agrobacterium tumefaciens* is an indispensable element for the induction of tumors in *D. stramonium*.
74. Effect of temperature on the reaction of *D. stramonium* L. plants infected with potato virus X.
75. Ultrastructure of *D. stramonium* leaves infected with the physalis mottle strains of belladonna mottle virus.
76. Biosynthesis of tropic acid.
77. Biosynthesis of the isovaleryl and senecieryl moieties of tropane alkaloids.
78. Effect of amino acids on the growth and formation of tropane alkaloids in the extirpated embryo of *D. stramonium* L.
79. Distribution of potato virus X in a tissue culture of jimsonweed (*D. stramonium*)
80. [Induction of tumors by the thermostable endotoxin of *Agrobacterium tumefaciens* on *D. stramonium* L.
81. *D. stramonium* as a narcotic.
82. An electron microscope study of the distribution of tomato spotted wilt virus in systemically infected *D. stramonium* leaves.
83. Effect of artificial shading on nitrogen metabolism of *D. stramonium* plants attacked by X-virus.
84. Production of scopolamine and hyoscyamine by *D. stramonium* L. suspension cultures.
85. Experiments with gibberellic acid on dwarf-mutants of *D. stramonium* L. var. *godronii* Danert. Cultivation research on medicinal plants.
86. Effects of beta-hydroxyethylhydrazine on growth and alkaloid formation of *D. stramonium*.
87. Visualization of tobacco mosaic virus in local lesions of *D. stramonium*.
88. Application of ultrasound for increasing alkaloid yield from *D. stramonium*.
89. Comparative studies on *D. stramonium* and its symbiotic micro-organism.
90. Effect of various concentrations and frequency of application of gibberellic acid on growth and formation of metabolic products of *D. stramonium*.
91. Generative hybridization of *D. stramonium* and its importance in obtaining high quality drugs (*Folium stramonii*).
92. *D. stramonium* L.: new research on a drug with a long history.
93. Modern research on an ancient and classical drug: *D. stramonium* L.
94. On the nature and the future of changes produced in *Capsicum annum* L. var. *cayennense* following grafting onto *D. stramonium* L.
95. The effect of adipic acid and methylamine on alkaloid biosynthesis in certain members of the Solanaceae. I. *D. stramonium* Linné.
96. A study of the anatomical effects produced in the leaves of *D. stramonium* L. by the action of 2, 4-dichlorophenoxyacetic acid.
97. Effect of potassium ferrocyanide on *D. stramonium* L. leaves and on alkaloids and other compounds.
98. Pharmacognosy of seven varieties of *D. stramonium*.
99. Structure of the roots of *D. stramonium* L. and *D. tatula* L.
100. Case of acute poisoning with *D. stramonium*

(URL-66)

13. HERBERIUM



Figure-25 Herbarium sheet of *D. stramonium* (URL-67)



Figure-26 Herbarium sheet of *D. stramonium* (URL-68)



Figure-27 Developmental stage of *D. stramonium* fruit (URL-69)

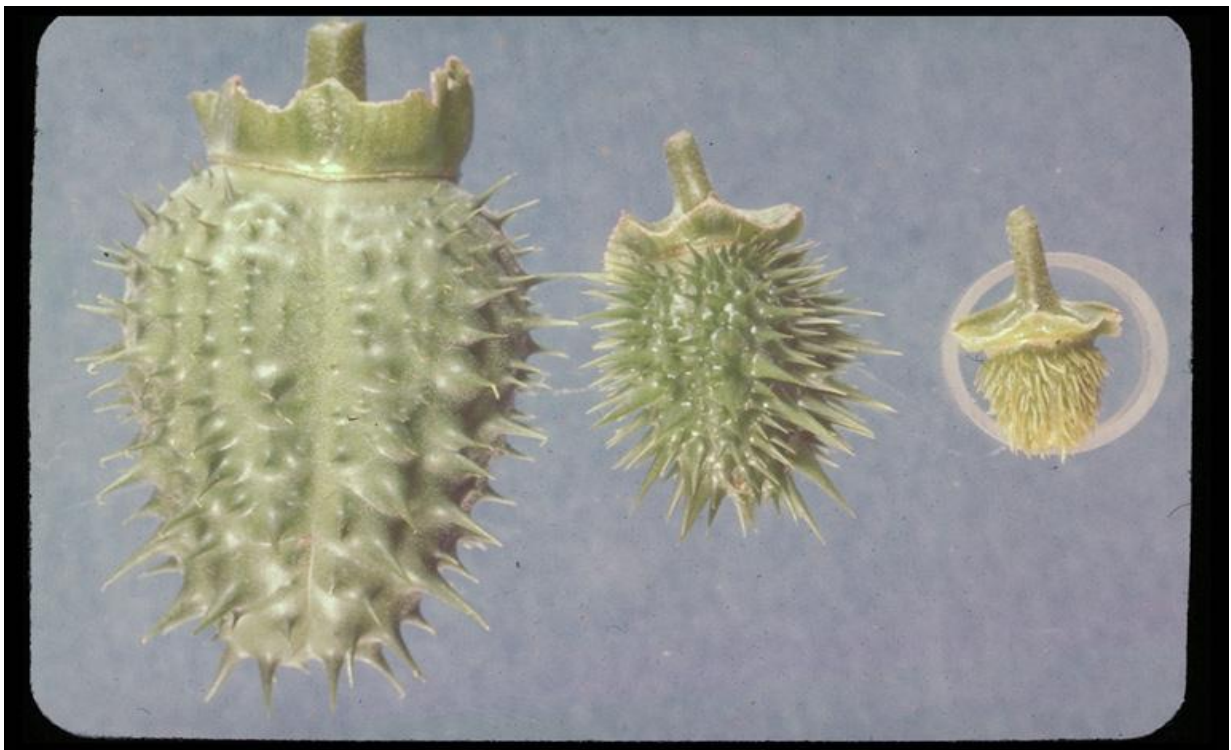


Figure-28 *D. stramonium* Fruit maturation (URL-70)



Figure-29 Plant of *D. stramonium* (URL-71)

14 GLOSSARIES

14.1 Glossary of Botanical Terms:

Alternate- Of leaves or branches that are arranged singly on the parent axis.

Axillary- Situated in an axil, referred especially to buds.

Blade- The flattened part of the thallus of the larger sea-weeds.

Bract- A small atypical leaf subtending a flower-bud in its axil.

Bracteate- Having bracts.

Complete flower- A flower having calyx, corolla, stamens and carpels.

Cordate- Heart shaped

Cortex- The tissue in a stem or root between the vascular bundles and the epidermis. Typically it is parenchyma.

Cross- The act of fertilization between two individuals of different breeds or races.

Cyme- An inflorescence in which the terminal bud is a flower-bud, i.e. it is a sympodium, and any subsequent flowers are formed in a similar way at the ends of lateral braches.

Diadelphous- Of stamens which have the filaments, either in two bundles or in a group with one free stamen.

Epidermis- The outer single layer of cells on an organ. The outer wall may be thickened by the production of a cuticle, and the cells may be extended into hairs.

Filament- The stalk of a stamen.

Flower- The reproductive stem of the angiosperms. Typically it is made up of a calyx of sepals, a corolla of petals, (these two being the perianth), an andrecium of stamens, and a

gynecium of carpels. Any of these parts may be missing in a particular flower. The floral axis is the receptacle.

Foliage leaf- An ordinary green leaf.

Glabrous- Hairless.

Globular- Nearly spherical.

Herb- A plant having no persistent parts above the ground.

Herbaceous- Soft and green, containing little woody tissue.

Hypodermis- A layer of one or more cells thick of thickened cells lying immediately below the epidermis.

Inflorescence- A flowering shoot, bearing more than one flower.

Kernel- The seed inside the stony endocarp of a drupe.

Lanceolate- Flattened, two or three times as long as broad common widest in the middle and tapering to a pointed apex.

Lenticel- A pore in the periderm of a woody stem. It is packed with a loose aggregate of cells derived from the phelloderm, and acts as an organ of gaseous exchange.

Oblong- Elliptical, blunt at each end, having nearly parallel sides and two to four times as long as broad.

Obtuse- Rounded or blunt; or being greater than a right-angle.

Ovary- The hollow basal region of a carpel, containing one or more ovules. In a flower with 2 or more united carpels, they form a single compound ovary.

Ovate- Flat and thin, shaped like the longitudinal section of an egg, widest below the middle.

Ovule- The nucellus containing the embryo sac and enclosed by 1 or 2 integuments, which after fertilization, and subsequent development, becomes a seed.

Palisade cells- A single cell of a palisade layer.

Palisade layer- A layer of elongated cells set at right-angles to the surface of a leaf or thallus, and underlying the upper epidermis, or layers of cells. Its cell contains numerous chloroplasts and is concerned with photosynthesis.

Palisade tissue- One or more layers of palisade cells beneath the epidermis of a leaf.

Parenchyma- A tissue of undifferentiated cells, which are more or less spherical, frequently unspecialized, and with cellulose cell-walls. Air spaces are often present, and the tissue is often for storage.

Pedicellate- Said of a flower or a fruit having a stalk.

Pedicels- The stalk of an individual flower of an inflorescence. A small stalk.

Pendulous- Said of an ovule which is suspended from a point at or near the top of the ovary.

Perennial- A plant living for three or more seasons and normally flowering and fruiting at least in the second and subsequent seasons.

Perianth- The flower envelope, it includes the calyx and corolla, or any one of them.

Pericycle- A cylinder of vascular tissue, 3-6 cells thick, lying immediately inside the parenchyma, and sometimes fibers.

Perisperm- A nutritive tissue present in some seeds, derived from the nucellus of the ovule.

Persistent perianth- A perianth which remains unwithered, and often enlarged around the fruit.

Petals- One of the parts forming the corolla of a flower, usually brightly colored and conspicuous.

Pistil- Each separate carpel of an apocarpous or syncarpous 2. The gynecium as a whole, whether it is apocarpous or syncarpous.

Pitted- Having pits in the wall, having the surface marked by small excavations.

Placenta- The part of an ovary to which the seeds are attached.

Plumule- The terminal bud of an embryo in seed plants. It is a rudimentary shoot.

Polyandrous- Having a large and indefinite number of stamens.

Polymorphism- The occurrence in the same habitat of two or more distinct forms of a species in such proportions that the rarest cannot be supposed to be maintained by recurrent mutation from any other.

Pubescen-t Covered with fine hairs.

Raceme- A definite inflorescence, with the main axis bearing stalked flowers which are born in acropetal succession.

Radicle- The embryonic root of seed plants; any very small root.

Raphe- The elongated mass of tissue, containing a vascular bundle, and lying in the side of an anatropous ovule, between the chalaza and the attachment to the placenta; a stit-like line running longitudinally on the vave of a diatom, indicating the position of a narrow slit in the wall, it bears a nodule at each end and one in the middle.

Seedlings- The young plant developed from a germinating seed.

Segregated- Keep separate; in taxonomy a group which is based on part of an earlier group.

Sessile- Lack of stalk.

Sheath- A leaf base, it forms a tubular casing around the stem.

Solitary- Of flowers occurring one in each axil.

Stamens- The microsporophyll of a flower; made up of the anther and filament.

Starch-grain- A round or irregular-shaped inclusion in a cell, made up of a series of layers of starch, giving a stratified appearance, and surrounding a central hilum.

Stele- The vascular cylinder. The cylinder or core of vascular tissue in the centre of stems and roots. It consists of xylem, phloem, and pericycle, in some cases pith and medullary rays. It is surrounded by an endodermis. The detailed structure differs in different groups of plants.

Stellate- Star like.

Stigma- The receptive part of the stigma.

Stipules- Basal appendages of a leaf or petiole. They may photosynthesize, or be scales, and may protect the axillary buds.

Testa- The seed coat. It is derived from the integuments and is several layers thick. It is protective in function.

Trait- A character.

Trifoliate- Said of a compound leaf having three leaflets.

Truncate- Blunt-ended, as if cut off abruptly.

Turgid- Said of a young or soft plant member which is stiff or rigid owing to the internal pressure rising from a plentiful supply of water.

Vascular bundle- The longitudinal strand of conducting tissue, consisting essentially of xylem and phloem.

14.2 Glossary of Medical Terms:

Abortifacient- 1. Producing abortion. 2. An agent that produces abortion.

Abortion- Expulsion from the uterus of an embryo or fetus prior to the stage of viability (20 weeks' gestation or fetal weight <500g). A distinction made between abortion and premature birth: premature infants are those born after the stage of viability but prior to 37 weeks. Abortion may be either spontaneous (occurring from natural causes) or induced (artificial or therapeutic). 2. The arrest of any action or process before its normal completion.

Acne- An inflammatory follicular, papular, and pustular eruption involving the pilosebaceous apparatus.

Adjuvant therapy- Additional therapy given to enhance or extend primary therapy's effect, as in chemotherapy's addition to a surgical regimen.

Amenorrhea- Absence or abnormal cessation of the menses.

Anecdotal- report of clinical experiences based in individual cases, rather than an organized investigation with appropriate controls.

Anemia- Any condition in which the number of red blood cells per mm³, the amount of hemoglobin in 100 ml of blood, and/or the volume of packed red blood cells per 100 ml of blood are less than normal.

Anodyne- agent that relieves pain

Anorexia- Diminished appetite.

Antispasmodic- Preventing or alleviating muscle spasms (cramps).

Aphrodisiac- 1. Increasing sexual desire. 2. Anything that arises or increases sexual desire.

Arrhythmia- Loss or abnormality of rhythm denoting especially an irregularity of the heart beat.

Arthritis- Inflammation of a joint.

Asthma- An inflammatory disease of the lungs characterized by reversible (in most cases) airway obstruction. Originally, a term used to mean "difficult breathing"; now used to denote bronchial asthma.

Boil- SYN furuncle

Bronchitis- Inflammation of the mucous membrane of the bronchial tubes.

Bruise- An injury producing a hematoma or diffuse extravasations of blood without rupture of skin.

Calculi- Plural of calculus.

Calculus- A concentration formed in any part of the body, most commonly in the passages of the biliary and urinary tracts; usually composed of salts of inorganic or organic acids, or other material such as cholesterol.

Carrageenan- A polysaccharide vegetable gum obtained from Irish moss; a galactosan sulfate resembling agar in molecular structure.

Cellulite- Colloquial term for deposits of fat and fibrous tissue causing dimpling of the overlying skin.

Cellulitis- Inflammation of subcutaneous, loose connective tissue.

Colic- 1. Relating to the colon. 2. Spasmodic pains in the abdomen. 3. In young infants, paroxysms of gastrointestinal pain, with crying and irritability, due to a variety of causes, such as swallowing of air, emotional upset, or overfeeding.

Contraception- An agent for the prevention of conception.

Delirium- An altered state of consciousness, consisting of confusion, distractibility, disorientation, disordered thinking and memory, defective perception (illusions and hallucinations), prominent hyperactivity, agitation and autonomic nervous system over activity, caused by a number of toxic, structural and metabolic disorders.

Delusion- A false belief or wrong judgments held with conviction despite in controvertible evidence to the contrary.

Depression- A temporary mental state or chronic mental disorder characterized by feelings of sadness, loneliness, despair, low self-esteem, and self-reproach; retardation or less frequently agitation, with-drawl from social contact, and vegetative states such as loss of appetite and insomnia.

Diabetes- Either d. insipidus or d. mellitus, diseases having in common the symptom polyuria; when used without qualification.

Diuretic- 1. Promoting the excretion of urine. 2. An agent that increases the amount of urine excreted-

Dizziness- Imprecise term commonly used to describe various symptoms such as faintness, giddiness, imbalance, light-headedness or vertigo.

Dropsy- Old term for generalized edema, most often associated with cardiac failure.

Dysentery- A disease marked by frequent watery stools. Often with blood and mucus, and characterized clinically by pain, tenesmus, fever, and dehydration.

Dyskinesia- Difficulty in performing voluntary movements.

Dyspepsia- Impaired gastric function or "upset stomach" due to some disorder of the stomach, characterized by epigastric pain, sometimes burning, nausea and gaseous

Eczema- Generic term for inflammatory conditions of the skin, particularly with vesiculation in the acute stage, typically erythematous, edematous, popular, and crusting; followed often by lichenification and scaling and occasionally by duskiness of erythema and , infrequently hyperpigmintation.

Edema- An accumulation of an excessive amount of watery fluid in cells or intercellular tissues.

Elephantiasis- Hypertrophy, edema and fibrosis of the skin and subcutaneous tissue, especially of the lower extremities and genitalia with hydrocele or enlargement of a limb, usually caused by long standing obstructed lymphatic vessels, most commonly the result of years of infection by the filarial worm *Wuchereria bancrofti* or *Brugia malayi*.

Epilepsy- A chronic disorder characterized by paroxysmal brain dysfunction due to excessive neuronal discharge, and usually associated with some alteration of consciousness. The clinical manifestations of the attack may vary from complex abnormalities of behavior including generalized or focal convulsions to momentary spells of impaired consciousness.

Eruption- 1. A breaking out, especially the appearance of lesions on the skin. 2. The passage of a tooth through the alveolar process and perforation of the gums.

Expectorant- 1. Promoting secretion from the mucous membrane of the air passages or facilitating its expulsion. 2. An agent that increases bronchial secretion and facilitates its expulsion.

Flatulence- Presence of an excessive amount of gas in the stomach and intestine.

Furuncles- A localized pyrogenic infection, most frequently by *Staphylococcus aureus*, originating deep in a hair follicle. SYN boil, furunculus.

Galactorrhea- Any white discharge from the nipple that is persistent and looks like milk.

Hallucination- The apparent, often strong subjective perception of an object or event when no such stimulus or situation is present; may be visual, auditory, olfactory, gustatory or tactile.

Hemiplegia- Paralysis of one side of the body.

Hypercholesterolemia- The presence of an abnormally large amount of cholesterol in the blood.

Hypotension- Subnormal arterial blood pressure.

Insomnia- Inability to sleep, in the absence of external impediments, such as noise, a bright light etc, during the period when sleep should normally occur; may vary in degree from restlessness or disturbed slumber to a curtailment of the normal length of sleep or to absolute wakefulness. SYN sleeplessness.

Jaundice- A yellowish staining of the integument, sclerae, deeper tissues, and excretions with bile pigments, resulting from increased levels in the plasma.

Laxative- Causes evacuation of fluid excrement.

Libido- Conscious or unconscious sexual desire.

Liniment- A liquid preparation for external application or application to the gums; they may be clear dispersion, suspensions, or emulsions, and are frequently applied by friction to the skin; used as counterirritants, rubefacients, anodynes, or cleansing agents.

Menses- Menstrual period.

Migraine- A symptom complex occurring periodically and characterized by pain in the head (usually unilateral); vertigo, nausea and vomiting, photophobia, and scintillating appearance of light.

Miscarriage- Spontaneous expulsion of the products of pregnancy before the middle of the second trimester. SYN spontaneous abortion.

Oligospermia- A subnormal concentration of spermatozoa in the penile ejaculate.

Orthostatic- Relating to an erect posture or position.

Palpitation- forcible or irregular pulsation of the heart, perceptible to the patient, usually with an increase in frequency or force, with or without irregularity in rhythm.

Pimple- A papule or small pustule; usually meant to denote an inflammatory lesion of acne.

Pyrexia- fever.

Scar- Fibrous tissue replacing tissues destroyed by injury or disease.

Scurvy- A disease marked by inanition, debility, anemia, and edema of the dependent parts; a spongy condition sometimes the ulceration of the gums and loss of teeth, hemorrhages and poor wound healing; due to a diet lacking vitamin C.

Secretagogue- an agent that promote secretion.

Spermatorrhea- An involuntary discharge of semen, without orgasm.

Teratogen- a drug or other agent that causes abnormal prenatal development.

Teratogenesis- The origin of mode of production of a malformed conceptus; the disturbed growth processes involved in the production of a malformed neonate.

Teratogenic- 1. Relating to teratogenesis. 2. Causing abnormal prenatal development.

Tonic- In a state of continuous unremitting action; denoting especially a prolonged muscular contraction; increasing physical and mental strength.

Ulcer- A lesion through the skin or a mucous membrane resulting from loss of tissue, usually with inflammation.

Vermifuge- An agent that destroys or expels intestinal worms. SYN anthelmintic

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