NAPPO

ORGANISATION NORD-AMERICAINE POUR LA PROTECTION DES PLANTES
NORTH AMERICAN PLANT PROTECTION ORGANIZATION
ORGANIZACION NORTEAMERICANA DE PROTECCION A LAS PLANTAS

PEST FACT SHEET
Solanum carolinense L.

Occasionally cultivated but rhizomatous rootstocks have caused this plant to be better known as a pernicious weed than as an ornamental. A perennial that inhabits cultivated fields, gardens, pastures, old fields, roadsides and disturbed areas and spreads by seed and underground rhizomes it is recognized as a weed in grain crops.

Preferred Scientific Name *Solanum carolinense* L.

Common Names

English: horse-nettle, Carolina horse-nettle, Carolina nettle, bull-nettle, bullnettle, ball- nettle, balle-nettle, ball nightshade, sand-brier, threadsoft, threadsaf, apple- of-Sodom, wild tomato, devil's tomato, devil's potato, sand briar, sand brier

French: morelle de Caroline, morelle de la Caroline

Spanish: ortiga de caballo

Germany: Carolina-Nachtschatten

Japan: warunasubi

Notes on Taxonomy

Solanum carolinense is divided into three varieties: *Solanum carolinense* var. *carolinense*, *S.c.* var. *floridanum*, and *S.c.* var. *hirsutum* (USDA, NRCS 1999).

Habitat

S. carolinense is native to the Gulf States (Bassett and Munro 1986) and is considered troublesome in the temperate to tropical zones of North America, Europe and Asia. It grows as a weed in grain and vegetable fields, orchards, pastures and nurseries. It is also found on roadside, in waste areas, riverbanks and, occasionally, in gardens growing in a wide range of soil types, but thriving in sandy or gravelly soils. The plant grows rapidly during hot weather and will tolerate drought (Bradbury and Aldrich 1957).

Distribution List

Asia

Bangladesh (Holm *et al.* 1979)
Georgia (Republic) (Trapidze 1972)
India (Zutshi & Kaul 1974)
Japan
- Hokkaido (Samejima *et al.* 1993)
- Honshu (Takei 1997)
- Kyushu (Osada *et al.* 1967)
- Ryukyu Archipelago (Hatsusima 1975)
- Shikoku (Abe 1990)

Nepal (Holm *et al.* 1979)

Europe

Croatia - (Gazi Baskova & Segulja 1978)
Norway - (Ouren 1987)

North America

Canada **-** BC ON QC
Mexico **-** northern Mexico (CDA 2003), Sonora (GRIN / NPGS taxon. Info.), Tamaulipas, Nuevo Leon (states bordering Texas (REMIB 2003)
USA - Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nebraska, New Mexico, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin (USDA, NRCS 2002)

South America

Haiti (D'Arcy 1974)
Brazil (D'Arcy 1974)

Oceania

Australia (Parsons & Cuthbertson 1992)
New Zealand - eradicated (Upritchard 1986)

Distribution Notes

The species is found throughout the eastern deciduous forest of North America but is less plentiful toward Florida. Native to the Gulf States, it has spread across almost all of the USA and into southern Ontario (Bassett and Munro 1986; USDA, NRCS 1999). North of the coastal plain it dies to the ground and overwinters by means of its elongate, tuberous roots. Reported from Brazil and occasionally from tropical countries, it is probably native to the eastern US, north to southern Ontario (introduced farther northward) but has been reported from various western states and Haiti, it appears to be better adapted to seasonally cold climates (D'Arcy 1974).

The distribution areas of *Solanum carolinense* var. *floridanum* and *S. c.* var. *hirsutum* are restricted to Florida and Georgia, and Alabama and Georgia, USA, respectively (USDA, NRCS 1999).

S. carolinense is thought to have been introduced into Japan about 100 years ago (Tsuji, 1906) and has spread over all of the islands. It has also been recorded in New Zealand (Healy 1982) but the weed may by now have been eradicated (Upritchard 1986).

Biology and Ecology

Found growing in shade or sun, in disturbed woodlands, pastures, beside culverts and around dwellings and frequently performs as a noxious weed (D'Arcy 1974). Locally common, a perennial that inhabits cultivated fields, gardens, pastures, old fields, roadsides and disturbed areas (Darbyshire 2003). The plant grows up to 100 cm with harsh spines along its stem that protects it from grazing animals. Up to 5000 seeds may be produced by a single plant and vigorous rhizomes can spread several meters.

S. carolinense is a perennial plant that propagates by seeds, roots and root cuttings. The germinable seed rate is very high in general, and seeds are considered to play an important role in the plant's dissemination (Ilnicki *et al.* 1962). Freshly harvested seeds are highly dormant, and alternating temperatures from 20 to 30°C increase germination. The seeds require temperatures above 15°C to germinate (Nishida *et al.* 2000). Light is not necessary for seed germination (Ilnicki *et al.* 1962) but may be involved in breaking dormancy (Suzuki 1975). The seedlings can emerge from depths of 10 cm (Ilnicki *et al.* 1962) and seeds retain their viability for at least 3 years when buried at depths

of 8 - 12 cm (Brown
and Porter 1942).

S. carolinense grows well in sunny environments (Takematsu *et al.* 1979). The plant appears to thrive on sandy or gravelly soils, but will grow in any type of soil (Bradbury and Aldrich 1957). Warm temperatures (Nishida *et al.* 1999a) and soil fertility favour growth. The plant has an extensive root system, and is drought tolerant (Bradbury and Aldrich 1957). Roots are apparently susceptible to freezing temperatures; hence distribution in Canada is restricted to regions where deeply penetrating roots remain below the frost line; shoots are also killed by frost (Bassett and Munro 1986).

S. carolinense is disseminated by seeds, roots and root cuttings. Natural dispersal on a small scale could occur via seed dissemination. Horizontal roots can extend several metres from the taproot (Kiltz 1930) and contribute to small-scale dissemination. Seeds can maintain viability after passing through the digestive tract of cattle (Nishida *et al.* 1998), horses, pigs or sheep (Muensher 1955).

Tillage of fields infested with S. carolinense promotes the dissemination of the plant by cutting the roots and dragging them elsewhere (Urakawa 2000), provided that other favourable conditions such as good weather conditions, less competitive crop plants and ineffective weed control are available. Harvesting operations may transport mature berries to other places, which also encourages dissemination.

Large-scale dissemination can occur by the contamination of a crop or commercial seeds with *S. carolinense* seeds. *S. carolinense* is thought to have been introduced to Japan from the USA via contamination of pasture plant seeds (Tsuji 1906; Ono 1965) and in fodder crop (Nishida and Shimizu, 1999) but there is no definite evidence to support this theory (CABI. 2003).

Economic Impact

One of the commonest species of *Solanum* in Florida (D'Arcy 1974), Solanum carolinense is reported as poisonous to livestock and the tubers contain crystals of calcium oxalate (Metcalfe & Chalk 1950). A long-lasting perennial with expanding patches that will infest vegetable fields, especially on sandy fields. A host of for insects and diseases of crop plants and is considered poisonous to sheep, cattle and humans.

CABI. (2003) lists the primary "hosts" of this weed as *Arachis hypogaea* (groundnut), *Camellia sinensis* (tea), *Cynodon dactylon* (Bahama grass), *Dactylis glomerata* (orchardgrass), *Fragaria ananassa* (strawberry), *Glycine max* (soyabean), *Lycopersicon esculentum* (tomato), *Malus pumila* (apple), *Medicago sativa* (lucerne), *Phalaris arundinacea* (Reed canarygrass), *Phaseolus vulgaris* (common bean), *Poa pratensis* (Junegrass), *Solanum tuberosum* (potato), *Zea mays* (maize).

S. carolinense is listed as a noxious weed under the Seeds Act and Regulation administered by Agriculture Canada (Bassett and Munro 1986). It is also listed in the Noxious Seeds Act of Manitoba. This species is a declared noxious weed and/or noxious-weed seed in 38 states of the USA (USDA, NRCS 1999) and is classed as one of the 10 most troublesome pasture weeds in the south-eastern USA (Smith and Calvert 1980).

The plant causes yield losses due to its competition with crops. The presence of S. carolinense fruits in groundnut harvests affects the grade or quality assigned to the groundnuts (Woodruff 1966). Frank (1990) reported that *S. carolinense* grown for 3 years and 1 year prior to planting snapbeans (*Phaseolus vulgaris*), reduced yield by 48-65% and 18-20%, respectively. Hackett *et al.* (1987) observed that maintaining a weed-free environment for 2 or more weeks in a field previously infested with *S. carolinense* permitted an increase in the yield of runner-type groundnuts.

S. carolinense is also an important alternate host for insect pests of crop plants such as the Colorado potato beetle (*Leptinotarsa decemlineata*) (McIndoo 1935) and the pepper maggot (Zonosemata electa) (Foott 1963). It is also host for the potato psyllid (Paratrioza cockerelli [Bactericera cockerelli]), which transmits psyllid yellow disease to potatoes and tomatoes (Wallis 1951), tomato leafspot fungus (Septoria lycopersici) (Pritchard and Porte 1921) and several viruses (Weinbaum and Milbrath 1976; Ramsdell and Myers 1978).

Morphology

Solanum carolinense is an herbaceous perennial plant, ranging from 20 to 120 cm in height erect and loosely branched. The stem is simple and erect, though sometimes prostrate and branching from the root. A more or less contorted root varying from .3 to .75 cm in diameter and having a thick bark surrounding a slender woody center, it descends deeply and vertically into the soil. The leaves are alternate, oblong, ovate; obtusely lobed, wavy, with yellowish prickles on midrib and larger veins of both surfaces, and extending along the petiole and main stem, where they become quite stout.

The plant has an extensive root system with taproots and creeping, horizontal roots. Kiltz (1930) showed that vertical taproots would grow to depths of 2.4 m and that horizontal roots were found in the upper 45 cm of soil. The horizontal roots (themselves sprouting shoots) can spread to several metres from the taproots.

The surfaces of stems and leaves are stellate (4, 6, or 8-rayed) pubescent. The leaves are alternate, simple and ovate to oblong in outline, with unevenly-lobed, toothed or deeply-cut margins. They are 4-14 cm long and about half as wide. Both surfaces are stellate-pubescent with yellowish hairs. There are sharp, yellow prickles on the veins, midrib and petioles.

The flowers are borne in simple racemes, becoming lateral in fruit. Flowers are regular, calyx 5-parted, sepals pointed, corolla rotate, with 5 ovate lobes and pale-blue, violet, or more rarely white. Stamens 5, yellow, inserted on the corolla; anthers 4-celled, 4 times as long as the filaments, and opening by pores at the tip. They are connivent and form a cone around the pistil. The style and stigma are single. The berries are globular, pulpy, juicy and smooth, each from 8 to 20 mm diameter. Immature berries are green, often with dark streaks. The mature berries are yellow, pale or yellowish-orange. A berry generally contains 40-170 seeds. The dried fruit has a shrunken or reticulated appearance.

The seeds are obovate, flattened and slightly granulose. They are about 2-3 mm diameter and 0.5 mm thick. The mature seeds are pale to dark yellow, light brown or orange.

Control (CABI 2003)

Prevention

As it is very difficult to control well-entrenched infestations of *S. carolinense*, prevention of its establishment is the most important and efficient means of control. Animal wastes which may contain viable seeds of S. carolinense should be treated before being used as manure. *S. carolinense* seeds lose viability when exposed to temperatures of 55 and 60°C for 72 h and 24 h, respectively (Nishida *et al.*, 1999b). These temperatures and durations are considered adequate if the animal waste is fermented properly.

Cultural Control

Ilnicki *et al.* (1962) reported that clipping the top growth, at least in July and August, prevented *S. carolinense* from producing viable seeds. As *S. carolinense* has an extensive root system and small root cuttings can produce shoots, tillage is believed to enhance the spread of the weed (Ilnicki *et al.* 1962, Takematsu *et al.* 1979, Smith and Calvert 1980). However, *S. carolinense* has been reported to have become prevalent in conservation tillage systems (Burnside 1981; Elmore *et al.* 1984). Young *S. carolinense* plants which sprout from root cuttings may be more susceptible to suppression by crop plants, and chemical and cultural control than well established plants. Muensher (1955) mentioned that a rotation which includes a clean cultivated crop every few years may reduce the presence of the weed, if the scattered plants appearing after the cultivation are hoed or pulled out.

Regehr and Janssen (1989) observed that the *S. carolinense* population declined significantly in ridge-till systems of a soybean and sorghum rotation with herbicide treatments.

Biological Control

Izhevskii *et al.* (1981) studied the integrated control of *S. carolinense* using Tobacco mosaic virus str. Alke (TMV) and herbicides. The application of TMV to *S. carolinense* prior to or during early bud formation gave satisfactory control of the weed in tea plantations. A prior herbicide treatment is recommended to reduce the leaf surface area of other weeds, and to ensure that the virus spray is deposited only on *S. carolinense* leaves.

Chemical Control

S. carolinense is susceptible to a wide range of herbicides. Some are effective in the short term, while others demonstrate long-term effectiveness. Albert (1960) concluded that in a pasture of Bermuda grass (*Cynodon dactylon*), the summertime application of 2,4-D over a course of several years would be practical, although the Ontario Weed Committee lists *S. carolinense* as resistant to 2,4-D (Bassett and Munro 1986). Foliar application of picloram in summer is very effective in controlling the root system and shoots of *S. carolinense*. However, picloram poses a greater problem with persistence and its potential dispersion in the environment. Triclopyr, which is as effective as picloram when used at higher rates, may be appropriate for use in controlling *S. carolinense* in pastures (Gorrell *et al.* 1981).

Glyphosate is most effective when applied during the fruit-bearing period (Banks *et al.* 1977, Nashiki *et al.* 1985). Whitwell *et al.* (1980) reported that a high temperature (32°C) resulted in more effective injury to the shoot but a low temperature (13°C) during glyphosate treatment resulted in much less regrowth.

Smith and Calvert (1980) reported that post-emergence applications of 2,4,5-T in water diluent effectively controlled *S. carolinense*. In maize, post-emergence application of dicamba may be advisable (Prostko *et al.* 1994). Talbert *et al.* (1982) reported that spot applications of acifluorfen were effective in controlling *S. carolinensis* and minimized potential damage to developing strawberry buds, although repeated applications at 2 to 3 week intervals were required. In groundnuts, subsurface layered dinitramine or post-emergence 2,4-DB application provided acceptable levels of control (Banks and Samtelmann 1978, Hackett *et al.* 1987).

S. carolinense is also suceptible to amitrole (Albert 1960), silvex [fenoprop], dinoseb (Banks *et al.* 1977), terbacil (Pagano 1975) and maleic hydrazide (Takematsu *et al.* 1979). The seedlings are suceptible to atrazine, cloransulam and metribuzin (Vangessel 1999).

When herbicides are used, it is necessary to adhere to local restrictions and regulations governing herbicide use.

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