Management of Nematodes and Soil Fertility with Sunn Hemp Cover Crop[1]

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Introduction

Sunn hemp, *Crotalaria juncea* L. is a rapidly growing crop that is used for fiber production in India and Pakistan. It is most popular as a green manure in many tropical and subtropical areas in the world as an organic nitrogen source. Recently, there is a growing interest in rotating sunn hemp with cotton in the southern United States and in using sunn hemp as a summer cover crop in Florida and other southeastern states. Sunn hemp suppresses weeds, slows soil erosion, and reduces root-knot nematode populations (Rotar and Joy 1983). When plowed under at early bloom stage, nitrogen recovery is the highest. Under optimum growing conditions such as in Hawaii, 'Tropic Sun' sunn hemp can produce 134 to 147 lb/acre of nitrogen (N) and 3 tons/acre air-dry organic matter at 60 days of growth at 40 kg seed/ha (Rotar and Joy 1983). In northern Florida, sunn hemp is usually grown in the summer and can produce 2.4 tons/acre of dry biomass and 98 to 125 lb N/acre (Marshall, 2002). In southwestern Alabama, plants grown for 9 to 12 weeks produced 2.6 tons/acre dry-matter and 112 lb N/acre (Reeves et al. 1996). Although in the tropics, 'Tropic Sun' grows and produces seed year-round at elevations of 0 to 900 ft, and in summer up to 1800 ft, sunn hemp does not set seed well in Florida (R. Gallaher personal communication). Sunn hemp is usually planted in summer in Florida (Rotar and Joy 1983), but it is suitable as a green manure crop as far north as Maryland. The greatest challenge in using sunn hemp as a cover crop in US is seed availability (see section below). Detailed cultivation and other ecological information on sunn hemp can be obtained from http://www.hort.purdue.edu/newcrop/duke_energy/Crotalaria_juncea.html.

Figure 1. *Crotalaria juncea* at early flowering stage.

History

In 1958, the National Resources Conservation Service (NRCS) (formerly the Soil Conservation Service), and the University of Hawaii purchased seeds of *Crotalaria* from a farmer who was growing it as a cover crop on the island

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of Kauai. This germplasm was used to develop the sunn hemp cultivar 'Tropic Sun.' 'Tropic Sun' seed was released in 1982 by the NRCS and University of Hawaii (Rotar and Joy 1983). The Agricultural Research Services Poisonous Plant Laboratory and the University of Hawaii determined that seeds of this cultivar were not toxic to livestock, and the plant was resistant to root-knot nematodes (Rotar and Joy 1983).

Figure 2. *C. juncea* at vegetative stage.

Sunn Hemp as a Fertilizer

Sunn hemp is most commonly used as a green manure, where it is grown for 2 to 3 months before cash crop planting and then incorporated into the soil at early blooming stage. Besides use as a green manure, sunn hemp can also be used as organic mulch where the cover crop is mowed and left on the soil surface. The advantage of using a leguminous cover crop as an organic mulch rather than green manure is that this practice will slow down the release of nutrients from the crop residues, and allow the nutrients to be available for the subsequent cash crops over a longer period of time. It had been demonstrated that sunn hemp can be grown as a winter cover crop in Alabama, and leaving the residues on the soil surface over the winter resulted in the release of 67 to 71 lb N/acre (Reeves et al. 1996). Research done in south Florida suggested that when sunn hemp is used as green manure and organic mulch, it should be seeded at high rates (49–58 lb/acre) and the crop terminated at 10–12 weeks from the planting date (Abdul-Baki et al. 2001).

Currently, the greatest challenge in using sunn hemp as a cover crop in the US is seed availability. Recent research has attempted to increase this cover crop biomass production with minimum seeding rate, and also to increase seed production. Research in south Florida concluded that cutting sunn hemp stems at 1 ft above soil level 100 days after planting (when plants were about 5 ft tall) and allowing the plants to grow for an additional 70 days resulted in the highest quality of green manure harvested as compared to uncut or cutting at a higher stem height. This is because cutting at 1 ft increased leaf yield (Abdul-Baki et al. 2001). This increased the N content of the biomass harvested because leaf tissues contained higher concentration of N (3.96%) than the stem tissues (0.88%) and whole plant tissues (2.5%) (Marshall 2002).

Since most of the macro-nutrients in sunn hemp are found in leaves and flowers, use of sunn hemp as green manure or organic mulch would be most beneficial at the early to mid-blooming stage (Marshall 2002). Sunn hemp is a short-day crop, which means that it will only flower in fall when day length becomes shorter in north Florida. However, sunn hemp is very susceptible to frost kill, and so opportunity for growth and biomass increase is limited by cool temperature in the fall. Therefore immediate use of sunn hemp residues is limited to supplying nutrients only to benefit winter vegetable crops. Therefore, another option for use of a sunn hemp cover crop is to harvest the cover crop residues, air dry, grind up the residues, and store as organic fertilizer for later use (Marshall 2002). While this form of application is time consuming, it offers opportunities to manipulate fertilizer application rate and timing.

Seaman et al. (2004) reported that frequent harvest of the top 18 inches of new growth by clipping sunn hemp at 16 to 32 inches height above soil line produced an organic fertilizer of 4% N. This means that if 3 tons/acre of dried sunn hemp clipped biomass is harvested as described above, it will contain 240 lb of N. Therefore, this high concentration of N in clipped sunn hemp materials has great potential as an organic N fertilizer.

The whole plant sunn hemp residues harvested at early blooming stage contained N-P_2O_5-K_2O in amounts of 123-42-80 lb/acre, which gives a ratio of 3:1:2 (Marshall 2002). Using this ratio, one can formulate a fertilizer according to the specific crop nutrient requirement. Marshall (2002) demonstrated that sunn hemp residue supplied N levels comparable to those derived from inorganic N for bush bean (*Phaseolus vulgaris*), lima bean (*P. lunatus*), okra (*Abelmoschus esculentus*), cucumber (*Cucumis sativus*), cowpea (*Vigna unguiculata*), sweet corn (*Zea mays*), and squash (*Cucurbita pepo*).

Nematode Suppression

Suppression of plant-parasitic nematodes by *Crotalaria* spp. has been known for decades. Godfrey (1928) noted that sunn hemp had few root galls from infection with root-knot nematodes (*Meloidogyne* spp.). Most of the plant-parasitic nematodes suppressed by *Crotalaria* are sedentary endoparasitic nematodes, which are nematodes that remain and feed in one place within the root system. These include root-knot, soybean cyst (*Heterodera glycines)* and reniform (*Rotylenchulus reniformis*) nematodes (Wang et al. 2002). Some migratory nematodes such as sting (*Belonolaimus longicaudatus*), stubby root (*Paratrichodorous minor*), dagger (*Xiphinema americanum*), and burrowing (*Radopholus similis*) nematodes were also suppressed by other plants in the genus *Crotalaria* (Wang et al. 2002). Table 1 summarizes results of studies on host status of sunn hemp and effects of using sunn hemp as a preplant cover crop or intercrop on various plant-parasitic nematodes.

How does sunn hemp suppress plant-parasitic nematodes?

Sunn hemp uses different modes of action to suppress plant parasitic nematodes, making it an efficient cover crop for nematode management. Sunn hemp is not only a poor host or nonhost to many plant-parasitic nematodes (Table 1), but it has been shown to produce allelopathic (toxic) compounds against several key nematode pests. Jasy and Koshy (1994) demonstrated that leaf extract of sunn hemp was lethal to burrowing nematode (*Radopholus similis*) at dilutions of 1:5 within 24 hours. Wang et al. (2001) also found that sunn hemp leaf leachate essentially stopped movement of the reniform nematode, *R. reniformis*.

Sunn hemp also can enhance natural enemies of plant-parasitic nematodes, such as fungi that trap nematodes or feed on their eggs (Wang et al. 2001). Besides suppressing plant-parasitic nematodes directly, sunn hemp can also manage nematode damage on crop indirectly by increasing plant tolerance against these pests. Sunn hemp amendments have been demonstrated to enhance free-living nematodes in the soil that are involved in nutrient cycling (Wang et al. 2003b), thus increasing nutrients available for plant uptake. A healthier plant will then have a higher tolerance to plant-parasitic nematode damage.

Pests and Diseases

The crop has few pest and pathogen problems. Major diseases of sunn hemp are *Fusarium* wilt caused by *Fusarium udum* var. *crotalariae* and anthracnose caused by *Collectotrichum curvatum* (Purseglove 1974). In Brazil, the only disease reported on the crop is *Ceratocystes fimbriata* (National Research Council 1979). The three most serious insect pests for sunn hemp are larvae of the sunn hemp moth, *Utetheisa pulchella;* the stem borer, *Laspeyresia pseudonectis;* and pod borers (Purseglove 1974). Pod borers can lower seed production of *C. juncea.* Sunn hemp is also a host to the stink bug, *Nezara viridula* in Hawaii (Davis 1964) and African sorghum head bug, *Eurystylus oldi* in France (Malden and Ratnadass 1998).

Seed Availability Problems

Shortage of seed supplies and increased seed prices are drawbacks for cover cropping of sunn hemp in the US. Retail market value of seeds currently averages $1.81/lb. An old recommended seeding rate for cover cropping is 40 to 60 lb/acre (Rotar and Joy 1983). This seed cost is discouraging to growers. However, recent work suggests that seeding rates of 10 lb/acre or less may be adequate, if planted in rows and if biomass is clipped and harvested at appropriate times (Marshall 2002). Expanding seed production of sunn hemp in the US beyond Hawaii is challenging. It is known that sunn hemp may not seed well north of 30° latitude. Climate in Florida should be suitable for sunn hemp seed production. However, in Florida, sunn hemp flowers well but seed production is poor. In southern Florida, Abdul-Baki et al. (2001) proposed to enhance sunn hemp seed production by increasing stem branching through pruning at 90 cm height.

How to enhance sunn hemp effects in suppressing nematode pests?

Although sunn hemp has good potential as a cover crop for managing several important plant-parasitic nematodes, the residual effects are short-term (a few months). While sunn hemp is a poor host to many plant-parasitic nematodes, nematode numbers can resurge to damaging levels on subsequent host crops (McSorley et al. 1994). This scenario strongly suggests that integrating the sunn hemp rotation system with other nematode management strategies is necessary. Among the possibilities for integration are crop resistance, enhanced crop tolerance, selection for fast growing crop varieties, soil solarization, and biological control.

Nematicides should be avoided in a cropping system if the objective is to enhance nematode-antagonistic microorganisms. Several studies have demonstrated the destructive effect of fumigation treatments to nematode antagonistic microorganisms. Sunn hemp could enhance activities of nematode-trapping fungi (NTF) in the rhizosphere or in soil amended with its biomass (Wang et al. 2001, 2003a), but it failed to enhance NTF populations in soils that were recently treated with the nematicide 1,3-dichloropropene (Wang et al. 2003a).

In summary, sunn hemp, besides serving as an efficient green manure, is a poor host to many important plant-parasitic nematodes, produces compounds toxic to nematodes, and is able to enhance some nematode-antagonisitc microorganisms. Therefore using sunn hemp as a cover crop could offer an alternative for managing nematodes. By integrating with other pest management strategies, the development of new sustainable cropping systems with sunn hemp is promising.

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Table 1. Host status and effects of using *Crotalaria juncea* in crop rotation or intercropping system on plant-parasitic nematodes (Wang et. al. 2002b).

Nematode	Host Status	Crop Rotation or Intercropping Effect
Meloidogyne arenaria	Poor host (McSorley 1999)	-
M. exigua	Resistant (Silva et al. 1990a)	-
M. hapla	Roots almost totally galled, but few egg masses found (Martin 1958).	-
M. incognita race 1	Poor host (McSorley 1999), poorer host than cotton (Robinson and Cook 2001)	Suppressed numbers on cotton (Robinson et al. 1997).*
M. incognita race 3	Resistant (Santos and Ruano 1987)	-
M. javanica	Poor host (McSorley 1999); smaller giant cells (Silva et al. 1990b); no galls, no juveniles (Araya and Caswell-Chen 1994); galls visible (Martin 1958).	Suppressed numbers on taro (Sipes and Arakaki 1997); on tobacco (Shepherd and Barker 1993); on sugarcane (Moura 1991).
Pratylenchus brachyurus	Survived but failed to multiply (Charchar and Huang 1981)	-
P. zeae	Poorer host than sorghum but can penetrate roots (Silva et al. 1989).	-
Rotylenchulus reniformis	Poor host (Caswell et al. 1991; Wang et al. 2001; Silva et al. 1989; Robinson and Cook 2001)	Reduced numbers on pineapple (Wang et al. 2002).
Radopholus similis	Leaf extract at 1:5 dilution is toxic (Jasy and Koshy 1994)	Intercropping with banana reduced nematode numbers (Charles 1995); did not suppress the nematodes when grown as preplant cover crop without biomass incorporation (Inomoto 1994).
Helicotylenchus multicinctus	**	Intercropping with banana reduced nematode numbers (Charles 1995).
Hoplolaimus indicus	-	Intercropping with banana reduced nematode numbers (Charles 1995).
* Full citations of references listed in Table can be obtained from http://agroecology.ifas.ufl.edu/sunn%20hemp.htm. ** not measured.		