CAN SUNN HEMP BE USED FOR EXPERIENTIAL TEACHING?

Christina L. Martiney and Sharadchandra P. Marahatta

Science and Math Division, Kaua`i Community College

University of Hawai'i

INTRODUCTION

Sunn hemp, *Crotalaria juncea* L., (SH) (Fig. 1) is a tropical or sub-tropical fast growing fibrous legume native to the Indo-Pakistan sub-continent with a history that dates back to the beginning of agriculture practices (Rotar and Joy, 1983). When grown in tropical regions, SH is a year-round crop, however, in sub-tropical regions, SH is best grown as an annual summer cover crop (Rotar and Joy, 1983). When SH is used as a cover crop, it can suppress plant-parasitic nematodes such as root-knot nematode (Rotar and Joy, 1983) that can affect banana crops in Hawaii (Henmi and Marahatta, 2015), and reniform nematodes that can affect pineapple production (Fewkes and Marahatta, 2012). SH can also increase the population of beneficial nematodes in soil such as bacteria and fungi feeding nematodes (Marahatta et al., 2010) that have an integral part in nutrient cycling and are an indicator of overall soil health.

Fig. 1: Sunn hemp *(Crotalaria juncea)*

SHADE HOUSE EXPERIMENT I

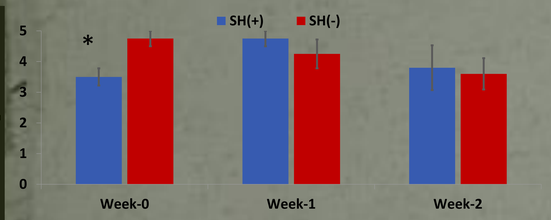

Fig. 2: Effects of soil incorporated sunn hemp (SH+) and no sunn hemp control (SH-) on corn germination at three seeding weeks. Means ± (SEM) are average of 4 replications.
* - Indicates a significant difference between SH(+) and SH(-) (P < 0.05). Seed germination was recorded after two weeks from planting.

SHADE HOUSE EXPERIMENT II

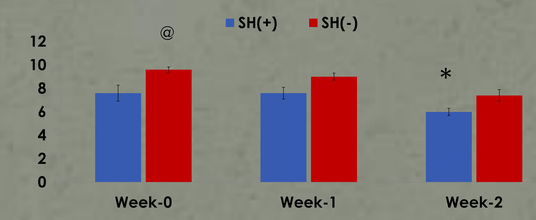

Fig. 3: Effects of soil incorporated sunn hemp (SH+) and no sunn hemp control (SH-) on corn germination at 4 seeding weeks in Trial-II. Means ± (SEM) are average of 4 replications.
@ and * - Indicate significant differences between SH(+) and SH(-) at P < 0.1 and P < 0.05, respectively.
Seed germination was recorded after 2 weeks from planting.

Fig. 4: Germinating corn seedlings in the Shade House experiment (II) at National Tropical Botanical Gardens.

DISCUSSION

The results of the Shade House Experiment-I, Field Experiment-II, and the seed germination trend of Shadehouse Experiment-II are consistent with the results of an earlier study where the use of SH reduced various vegetable seed germination (Skinner et al., 2012) confirming the allelopathic effect of SH on seed germination if cash crops are seeded immediately after mixing SH to the soil. Furthermore, the higher population of bacterivorous nematodes in cover crop incorporated treatments could be from the rapid cycling of organic materials as described by Wang and McSorley (2005), where higher populations of bacterivorous nematodes was found in the SH and soil mixed field experiment (Marahatta et al., 2010) and shadehouse experiment (Henmi and Marahatta, 2015). No herbivorous nematode in SH is probably the plant-parasitic nematode killing effects of SH released allelopathic chemical, monocrotaline, as described by previous researchers (Rotar and Joy, 1983; Wang and McSorley, 2005). Additionally, results of the High School Outreach-I and the trend of High School Outreach-II support that two weeks is sufficient to increase beneficial bacterivorous nematode, Rhabditidae's population on SH incorporated soil, as found by Wang et al. (2004) in letterbags, even in soil with little vegetation initially present in soils.

CONCLUSION

It is recommended that SH can be used as part of agricultural based instruction as a cover crop to enhance nutrient cycling with increased beneficial nematode populations as well as for suppressing plant-parasitic nematodes through SH's allelopathic effects. Furthermore, because of the consistent experimental results of SH on the enhancement of beneficial nematodes in soil within two weeks, SH can be used as an effective model plant for teaching soil ecology, plant biology, and agriculture in high school science classrooms. It is also recommended that instructors could use the allelopathic effect of SH to show that they should wait at least one week, but no longer than two weeks after SH incorporation to the soil for cash crop planting in order to obtain the best results for cash crop seed germination.

Fig. 5: Cover crops of sunn hemp, pigeon pea and fallow control at the Kaua`i Community College farm.

FIELD EXPERIMENT I

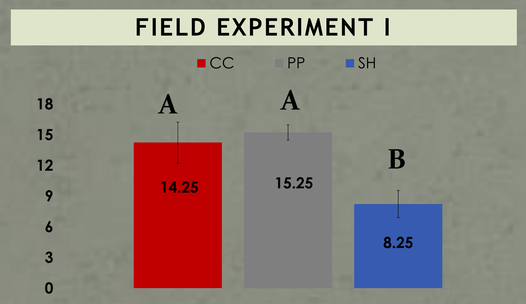

Fig. 6: Effect of soil incorporated Sunn hemp (SH), pigeon pea (PP) and fallow control (CC) on corn germination. Means ± (SEM) are average of four replications. Means followed by the same letter(s) do not differ according to Waller-Duncan K-ratio (K=100) t-test. Corn seeds were seeded immediately after cover crop incorporation into the soil.

FIELD EXPERIMENT II

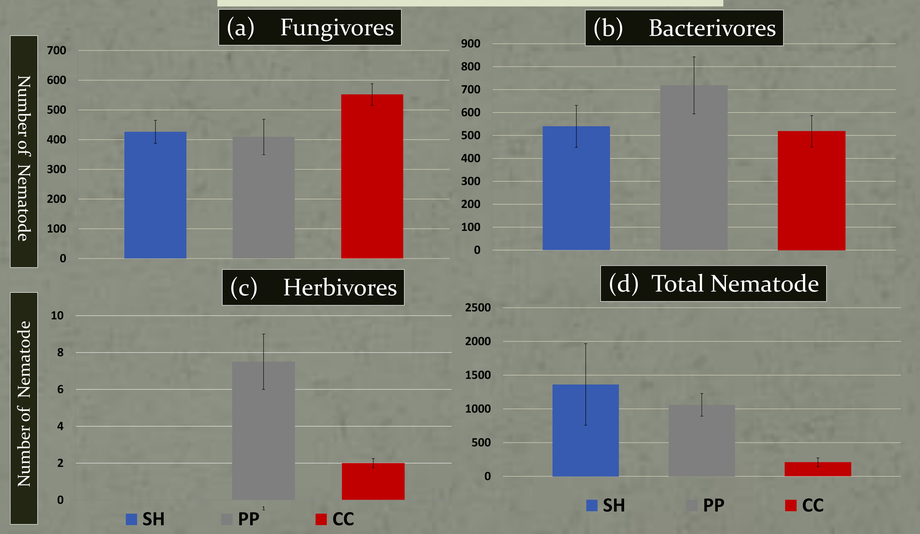

Fig. 7: Effect of soil incorporated sunn hemp (SH), pigeon pea (PP) and fallow control (CC) on fungivores (A), bacterivores (B), herbivores (C), and total nematode (D) populations. Means ± (SEM) are average of four replications.

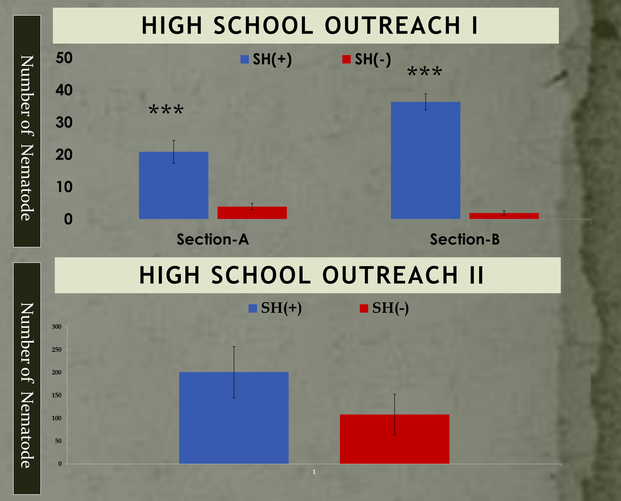

Fig. 8: Effects of soil incorporated sunn hemp (SH+) and no sunn hemp control (SH-) on bacterivorous nematode, Rhabditidae. Trials were conducted in two separate sections (section A and B) by Kauai High School, 10th grade biology students. Means ± (SEM) are average of 11 replications. *** - Indicate significant differences between SH(+) and SH(-) (P < 0.001). Fig. 9: Effects of soil incorporated sunn hemp (SH+) and no sunn hemp control (SH-) on bacterivorous nematode, Rhabditidae. Two trials were conducted and combined by Kauai High School, 10th grade biology students. Means ± (SEM) are average of 12 replications.

Methodology & Results

Shade House Experiment-I & II: Two Shade House experiments were conducted at Kaua`i Community College, Lihue, HI in the summer (Shade House Experiment-I) (Fig.2) and fall (Shade House Experiment-II) (Fig. 3 & 4), 2013. In both experiments, soil and fresh cut SH were gathered from the Kaua`i Community College farm. Soil was well mixed prior to placement into 10-cm diam plastic pots. Each pot was filled with approximately 400 cm3 field soil. A total of 24 pots were prepared and twelve pots were amended with fresh SH foliage at 1% (w/w) SH+, and 12 pots received no amendment SH-. In the pots, Zea mays, 'Hawaiian Supersweet #9' seeds were planted immediately (W-0), after 1 week (W-1), or after 2 weeks (W-2) of SH incorporation. Fresh SH foliage was used for soil amendment and prepared from field-grown SH plants. The experiment was a 3 × 2 (week × SH amendment) factorial experiment with 4 replications arranged in a RCBD. Seed germination was measured after 2 weeks from corn seeding. Field Experiment–I & II: The Field Experiment-I (Fig.6) was conducted on a student teaching plot at Kaua`i Community College, Lihue, HI in the spring, 2013. The study site consisted of two separate cover crop plots, SH, PP, and a CC. Each plot measured 2.25 m X 3.0 m with an inter- and intra-row spacing of 1.0 m. Cover crops were grown for 1 month, tilled, cover crop foliage incorporated into the soil and corn, *Zea mays* 'Hawaiian Supersweet #9,' seeds were sown immediately. One week after corn sowing, the number of germinated corn seedlings were recorded. Field plots were arranged in a randomized complete block design (RCBD) with four replications. Field Experiment -II: Field Experiment-II (Fig. 7) was conducted inside the breadfruit research field (Ulutopia) compound at Kaua`i Community College, Lihue, HI in the fall, 2015. The study site consisted of similar treatment plots (SH, PP and CC), design and replication as in Field Experiment-I. Each plot measured 3.66 m X 2.74 m with an inter- and intra-row spacing of .61 m. Cover crops were grown for 3 months, tilled, and cover crop foliage incorporated into the soil. As in Trial I, corn seeds 'Hawaiian Supersweet #9' were sown immediately after incorporating SH or PP into the ground and germinating seed were recorded at 1 week. Unlike Field Experiment –I, Field Experiment-II (Table 1) soil samples were taken and shipped to Earthfort Lab, OR., at three weeks of the soil and SH and PP incorporation for nematode extraction and identification. Identified nematodes were further analyzed and treatment effects were evaluated. High School Outreach: An experiment was conducted at Kauai High School (Fig. 8 & 9), Lihue, HI in the fall, 2014 with 10th grade biology students (High School Outreach-I) (Figs.). Soil was gathered from different locations on the school campus, and SH was gathered from the National Tropical Botanical Garden, Kalaheo, HI and air dried. Soil was well mixed prior to potting into 10-cm diam plastic pots. Each pot was filled with approximately 200cm3 soil. A total of 44 pots were prepared between two different classes. Twenty-two pots were amended with dried SH foliage at 1% (w/w) SH+, and 22 pots received no amendment (SH-). At 2 weeks after incorporation, nematodes were extracted by Baermann and funnel technique and observed under inverted microscopes (Flouvert, Leitz Wetzlar, Germany). The second high school outreach was conducted at Kauai High School, Lihue, HI in Fall 2016 with 10th grade biology students (High School Outreach-II). The High School Outreach-II was similar to the High School Outreach-I. However, Soil was gathered from one location with almost no vegetation on the school campus. A total of 24 pots were prepared between two different classes. Twelve pots were amended with dried SH foliage at 1% (w/w) SH+, and 12 pots received no amendment SH-. In addition to this, the High School Outreach-II students observed nematodes using compound microscopes.

Nematode	SH	PP	CC		SH	PP	CC
Bacterivores				**Omnivores**			
Acrobeles			15	*Discolaimium*			1
Alaimus			1	*Eudorylaimus*	15		1
Cephalobus	260	233	64	*Mesodorylaimus*		5	
Cervidellus	6	10		*Microdorylaimus*	19		
Diploscapter	6			*Tylencholaimus*		16	5
Eucephalobus		15	6	**Fungivores**			
Geomonhystera			1	*Aphelenchoides*	105	79	2
Monhystrella			2	*Aphelenchus*	528	280	39
Panagrolaimus	43	102	16	*Ditylenchus*	11	24	18
Plectus	15		2	*Filenchus*			1
Prismatolaimus	6	5	5	*Malenchus*			1
Rhabditidae	351	280	23	*Herbivores*			
Wilsonema			4	*Helicotylenchus*		5	2
				Paratylenchus		11	2

TABLE 1. Effects of sunn hemp (SH), pigeon pea (PP) and fallow control (CC) on beneficial and plant-parasitic nematode genera and their numbers in the field.

Fig. 10: Experiment setting with the students at Kaua`i High School.

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