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The Impact of Sunn Hemp Cover Cropping on Belowground Organisms and Nutrient Status Associated with a Cucumber Planting

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Summary

A field trial was conducted to examine the impact of growing sunn hemp (*Crotolaria juncea*) on belowground organisms such as plant-parasitic and beneficial nematodes and nematode-trapping fungi associated with a cucumber (*Cucumis sativus*) agroecosystem. Populations of plant-parasitic nematodes were not different between sunn hemp-cucumber and bare-ground cucumber plots at the end of cover crop season, but were greater ($P < 0.05$)* in the sunn hemp–cucumber plots at the end of cucumber harvest due to the greater cucumber plant stand in sunn hemp plots. Bacterial-feeding nematodes were found at higher densities in sunn hemp plots after its incorporation into the soil. Numbers of nematode-trapping fungi were also greater in plots containing sunn hemp. Despite the greater ($P < 0.05$) plant stand in sunn hemp plots compared to bare-ground cucumber plots, there were no significant differences in marketable yields. Potential reasons for the outcome and additional use of sunn hemp are discussed.

*The *P* value is a statistical estimate of the probability that a difference between treatments found during an experiment happened by chance. For example, a *P* value of 0.05 ($P = 0.05$) means there is a 5-in-100 chance that the result occurred by chance, and thus a 95 percent probability that the result occurred because of the effect of treatments. The lower the *P* value, the more likely it is that any difference between treatment data means was caused by treatment effect. Thus $P < 0.05$ means that the result has a better than 95 percent chance of being a valid result, while $P > 0.05$ indicates that less confidence can be placed in the result.

Introduction

Cover crops are non-cash crops that are typically grown during the off season or in companion with cash crops. Cover crops may aid in the control of insect pests, plant pathogens, and weeds; reduce soil erosion; improve soil structure or nutrient status; and increase soil organic matter content. Due to their ability to provide several valuable services to a farming operation, cover crops can be an important component of sustainable agriculture.

For this field trial, we chose to evaluate sunn hemp as a cover crop because it possesses several good characteristics. Sunn hemp

- is a poor host or non-host for a large diversity of pests and pathogens
- is competitive with weeds without becoming a weed
- increases above-ground and belowground beneficial organisms (e.g., predators, nematode-trapping fungi, nematode-antagonistic microorganisms)
- fixes nitrogen
- can be used as a green manure
- releases allelopathic compounds that are toxic to plant-parasitic nematodes
- helps suppress weed growth when its residues remain on the soil surface.

Increased knowledge of the positive and negative impacts of sunn hemp in agricultural systems may lead to novel insights required for their successful incorporation into sustainable management practices. Sunn hemp

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Picture 1: Rows of sunn hemp after they have been clipped.

and other cover crops are likely to play a significant role for organic farming and those agricultural establishments seeking greater sustainable production practices. This publication describes a field trial in which cucumbers were interplanted into sunn hemp to determine its impact on plant-parasitic nematodes as well as plant and soil nutrient contents.

Materials and methods

The field experiment was conducted during 2006–2007 on the island of O‘ahu, Hawai‘i, at Khamphout Farm in Kunia. At the request of the producer, the study was conducted in a field that had a history of poor yields and crop failures, possibly due to nematodes and other unidentified problems (e.g., soil-borne pathogens). A randomized complete block design with four replications of each treatment type was established. Experimental plots were 12 by 12 meters. The treatments included (1) cucumber interplanted with sunn hemp seeded at 45 grams per row and (2) cucumber monoculture. Nineteen sunn hemp rows were planted 61 cm (2 ft) apart on September 08, 2006, in sunn hemp treatment plots. The sunn hemp was trimmed on occasion to maintain a height of approximately 1.2 m (4 ft). In January 2007, alternate sunn hemp rows were cut using a weed eater and tilled under using a hand tiller. The neighboring rows were allowed to stand so as to collect sunn hemp seed at a later date for future plantings. One week later, cucumbers were transplanted into the sunn hemp–tilled rows and monoculture plots. Thus, the cucumber-sunn hemp and cucumber monoculture treatments consisted of nine and 10 rows of cucumbers, respectively. Cucumber plants were planted at 46 cm (1.5 ft) between plants and 1.2 m (4 ft) between rows. Cucumber plants were later

Picture 2: Cucumber interplanted with sunn hemp.

trellised. Cucumber harvesting was initiated in March and completed in April 2007. Samples for nematode determinations (i.e., beneficial and harmful nematodes) and plant and soil nutrient analyses were collected from all treatment plots during key periods of the experiment. Cucumber plant stands and subsequent yields in the treatments plots were documented.

Results

Nematode assay

Beneficial and harmful nematodes were categorized into four trophic groups: (1) bacterial-feeders, (2) fungal-feeders, (3) omnivorous and predatory nematodes (these three groups are beneficial), and (4) plant-parasitic nematodes (harmful). Bacterial-feeding nematodes commonly found included *Eucephalobus, Cephalobus, Acrobeles, Acrobeloides*, *Prismatolaimus*, and *Isolaimium*. Fungal-feeding nematodes commonly found at the site were *Aphelenchus, Aphelenchoides, Tylenchus, Psilenchus*, and *Filenchus.* Omnivorous and predatory nematodes included *Dorylaimus* and *Discolaimus.* The most dominant plant-parasitic nematodes found were *Meloidogyne* (root-knot), followed by *Scutellonema* (spiral) and *Xiphenema* (dagger).

Plant-parasitic nematode populations were not different between treatments for each time period ($P > 0.05$; Fig. 1) except for higher ($P < 0.05$) numbers of root-knot nematodes from sunn hemp treatments at harvest (Fig. 2). This was tentatively influenced by the significantly greater cucumber plant stand in sunn hemp compared to bare-ground plots (Table 4).

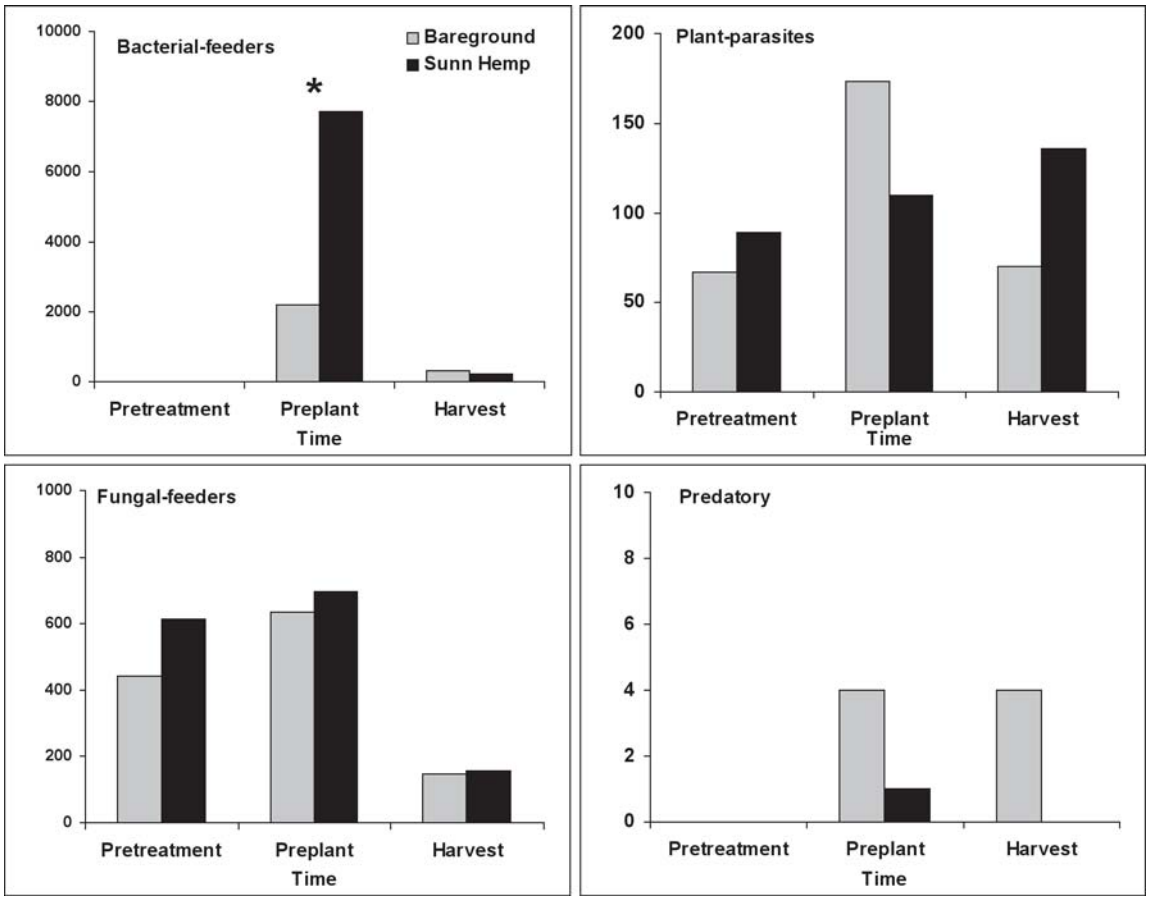

Figure 1. Numbers of bacterial-feeders, fungal-feeders, plant-parasitic nematodes, and predatory nematodes at pre-treatment (prior to cover crop planting), pre-planting (2 months after cover crop planting), and cucumber harvest (< 2 months after cucumber planting) in sunn hemp and bare-ground plots. An asterisk in a column indicates that the difference between bare-ground and sunn hemp treatments is significant at $P < 0.05$ according to analysis of variance.

Beneficial soil organisms

No differences ($P < 0.05$) were detected between sunn hemp and bare-ground treatments for the number of beneficial nematode groups found at initiation of the experiment (i.e., prior to cover crop planting). At termination of the cover crop season (i.e., sunn hemp strip tilled) and just prior to planting the cucumber crop, numbers of bacterial-feeding nematodes, which play an important role in soil nutrient cycling, were higher ($P < 0.05$) in sunn hemp plots (Fig. 1). However, this treatment effect on bacterial-feeding nematodes did not persist through the final harvest period. As such, no differences ($P > 0.05$) were detected between bacteria feeders found in sunn hemp and bare-ground plots at cucumber harvest. Sunn hemp treatment did not increase population densities of fungal-feeding, omnivorous, and predatory nematodes ($P > 0.05$, Fig. 1). However, at cucumber harvest there were higher ($P < 0.05$) numbers of nematode-trapping fungi, which are beneficial fungi that prey on plant-parasitic nematodes in sunn hemp treatment plots (Table 1).

Soil nutrient assay

No significant differences were found between sunn hemp and bare-ground treatments in all the soil nutrient analyses prior to cover crop planting (January) and at termination of the cover crop (March) (Table 2). After the cucumber harvest, percentages of carbon and potassium in the soil were significantly higher in sunn hemp plots, but soil nitrogen and calcium levels were similar in both habitat types. However, percentages of nitrogen and carbon content in the cucumber foliage were higher

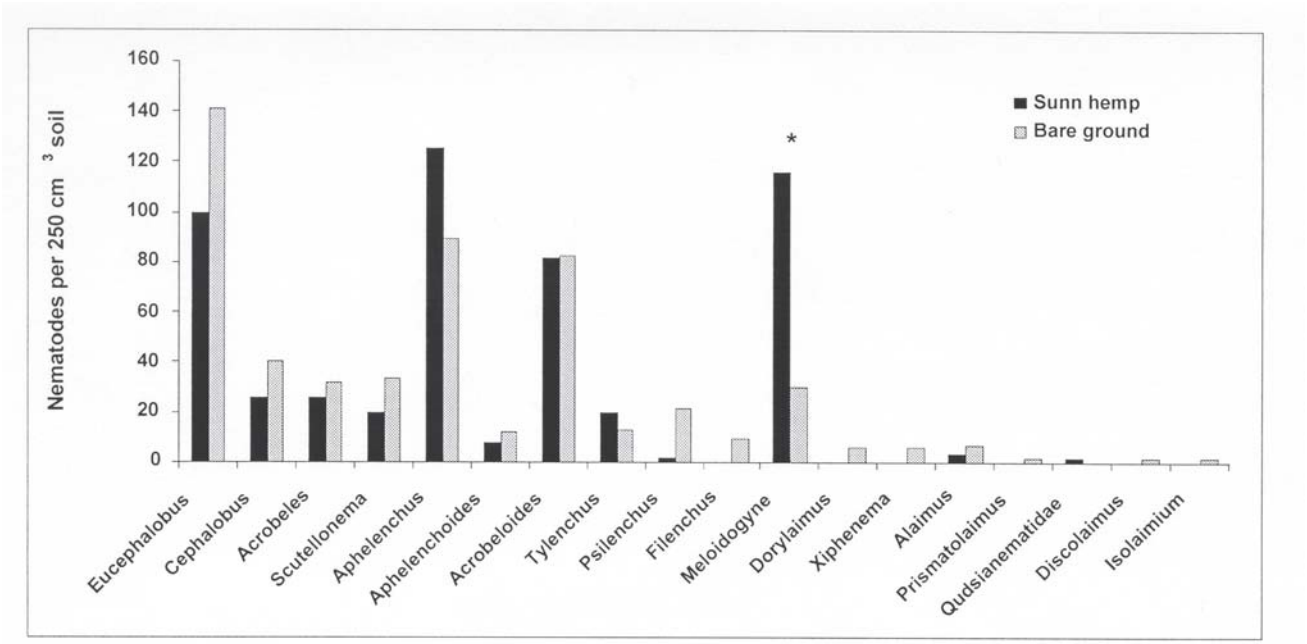

Figure 2. Numbers of nematode in each genus recovered at cucumber harvest in sunn hemp and bare-ground plots. For the column pair with an asterisk, there was a significant difference ($P < 0.05$) between sunn hemp and bare-ground plots according to analysis of variance.

Table 1. Effect of sunn hemp treatment on nematode-trapping fungi (propagules per gram soil) at termination of the cucumber crop, 27 April 2007.

	Arthrobotrys oligospora	*Monocosporium ellipsosporium*	*Monocosporium eudermata*	*Arthrobotrys brochopaga*	Total
Sunn hemp	3.97 ± 0 [a]	0 ± 0 [a]	4.30 ± 2.48 [a]	1.50 ± 1.72 [a]	3.37 ± 6.74 [a]
Bare ground	1.32 ± 1.32 [a]	1.32 ± 0.76 [a]	1.32 ± 0.76 [a]	0.71 ± 0 [a]	1.96 ± 2.48 [b]

Due to poor plant growth, no nematode-trapping fungi were detected from the first replication. Thus, means are averages of three replications. Means in a column followed by same letter are not different ($P > 0.05$) according to protective LSD mean separation based on square root transformation (√[0.5 + x]).

Table 2. Effect of sunn hemp treatment on soil nutrients and organic matter (carbon) before and after the cucumber crop.

	Nitrogen (%)	Carbon (%)	Calcium (ppm)	Potassium (ppm)
Jan. 2007				
Sunn hemp	0.13 ± 0.0025 [a]	1.44 ± 0.0918 [a]	2896 ± 1521 [a]	403 ± 37 [a]
Bare ground	0.13 ± 0.0025 [a]	1.36 ± 0.0330 [a]	1387 ± 48 [a]	352 ± 18 [a]
March 2007				
Sunn hemp	0.14 ± 0.0025 [a]	1.46 ± 0.0906 [a]	-	-
Bare ground	0.13 ± 0.0025 [a]	1.31 ± 0.0325 [a]	-	-
May 2007				
Sunn hemp	0.14 ± 0.0075 [a]	315 ± 0.1180 [a]	3080 ± 1635 [a]	315 ± 31 [a]
Bare ground	0.12 ± 0.0029 [a]	237 ± 0.0240 [b]	1333 ± 35 [a]	237 ± 12 [b]

Means are averages of four replications. Means in a column for each sampling date followed by the same letter are not different ($P > 0.05$) according to protective LSD mean separation. Mean separation for %N and %C are based on square root transformation (√[0.5 + x]), but only true means are presented.

($P < 0.05$) in sunn hemp treatments compared with bare-ground plots by the final harvest period (Table 3).

Table 3. Effect of sunn hemp treatment on leaf nutrients at termination of the cucumber crop, April 2007.

	% N	% C
Sunn hemp	6.13 ± 0.24 a	40.18 ± 0.55 a
Bare ground	4.88 ± 0.18 b	36.67 ± 0.60 b

Means are average of 24 replications. Means in a column followed by same letter are not different ($P > 0.05$) accorhÈng to protective LSD mean separation.

Crop yield

Although there is a trend toward greater total number of cucumber fruits and yields in sunn hemp treatments compared to bare-ground cucumber plots, there was no significant difference between the two treatments (Table 4). Overall yields were influence by cucumber plant stand, which was higher ($P < 0.05$) in sunn hemp plots than in bare-ground plots (Table 4). These differences in plant stand caused a significant amount of yield variation among plots.

Discussion and conclusion

During this field trial, there were some benefits to incorporating sunn hemp into the cucumber planting. These included an increase in the numbers of bacterial-feeding nematodes, which are involved in soil nutrient recycling, and of nematode-trapping fungi. These facultative fungi form trapping structure to catch, feed on, and eventually kill plant-parasitic nematodes. There was also an increase in percent nitrogen and carbon detected in the leaves of cucumber plants in sunn hemp plots compared to cucumber monoculture. In addition, the total cucumber plant stand was three times greater in sunn hemp plots compared to monoculture habitats. Despite these benefits, there were no significant difference in yields between sunn hemp and bare-ground treatments. The overall higher fruit numbers and yield in sunn hemp plots were negated by the number of cull fruits caused by melon fly (*Dacus cucurbitae*) stings. The standard practice for controlling melon fly includes planting sorghum along the field border and spraying it with GF-120 NF Naturalyte Fruit Fly Bait. Although sorghum was planted around the study site, fruit flies were observed roosting on the sunn hemp. Thus, in instances where sunn hemp is grown with a cash crop, it can possibly be used as a trap crop to manage fruit flies by spraying the bait directly on the sunn hemp. This might eliminate the need to plant sorghum borders and result in better fruit fly control.

Although sunn hemp is becoming increasingly popular for use as a cover crop, sunn hemp seed is not always readily available owing to the fact that the United States relies heavily on international imports. Intercropping sunn hemp with a cash crop will allow growers to harvest sunn hemp seed and maintain a seed source without taking the entire field out of cash crop production.

Lastly, one of the main purposes of conducting this trial was to determine if sunn hemp could be used to reduce populations of root-knot nematodes. However, higher root-knot nematode numbers were found in sunn hemp than monoculture cucumber treatment plots by final harvest. This may have been due to the fact that the poor cucumber stands in monoculture treatment plots provided limited amounts of roots for root-knot nematodes to feed on. Previously, the owner had discontinued use of the test field because of consistent crop failure and poor yields, and the field had been left fallow for some time. However, we chose to conduct the study at this site in the interest of the grower. The increase in cucumber plant stand in sunn hemp plots compared to monoculture plots suggests that growing the sunn hemp changed some properties at the field site that resulted in a healthier plant stand. Future studies may include: (1) investigating the cause of plant stand reduction and (2) determining why the cucumber plant stand was significantly greater when grown with sunn hemp.

In addition to sunn hemp, field studies are currently being conducted in California, Florida, and Hawai‘i to maximize the on-farm benefits of marigold (*Tagestes patula*) and cowpea (*Vigna unguiculata*). Our research aims include creating environments within crop fields that are conducive to good crop growth. We hope to increase the long-term viability of agricultural communities by providing growers with research-based information that increases their production efficiency, safeguards the environment, reduces risk, minimizes product loss, and safeguards farmers from economic hardship.

Table 4. Effect of sunn hemp treatment on cucumber yield harvested between 26 March and 22 April 2007.

	Sunn hemp	Bare ground
Cull fruit weight (kg/ha)	3450 ± 1794 [a]	1037 ± 628 [a]
Marketable fruit weight (kg/ha)	43 ± 22 [a]	67 ± 33 [a]
Total fruit weight (kg/ha)	3492 ± 1747 [a]	1104 ± 552 [a]
Cull fruit number/ha	16,172 ± 8086 [a]	6522 ± 3261 [a]
Marketable fruit number/ha	263 ± 132 [a]	296 ± 148 [a]
Total fruit number/ha	16,436 ± 8218 [a]	6818 ± 3409 [a]
Plant stand	115 ± 30 [a]	35 ± 16 [b]

Means are average of 4 replications. Cull fruits are fruit containing melon fly (*Dacus cucurbitae*) stings. Means in a row followed by same letter are not different ($P > 0.05$) according to protective LSD mean separation procedure.

References and further reading

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