REVITALIZED DEGRADED SOIL IN THE TROPIC WITH ENERGY SORGHUM

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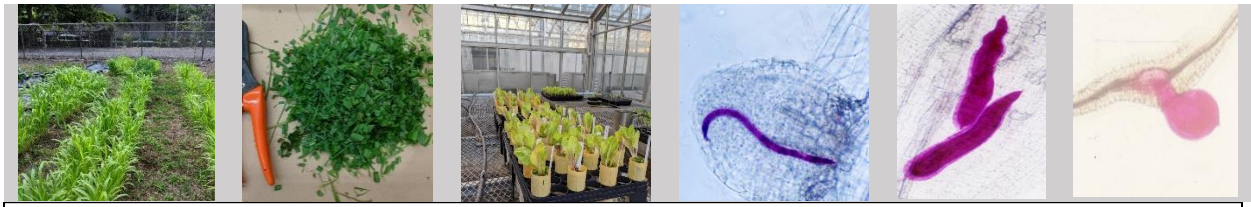
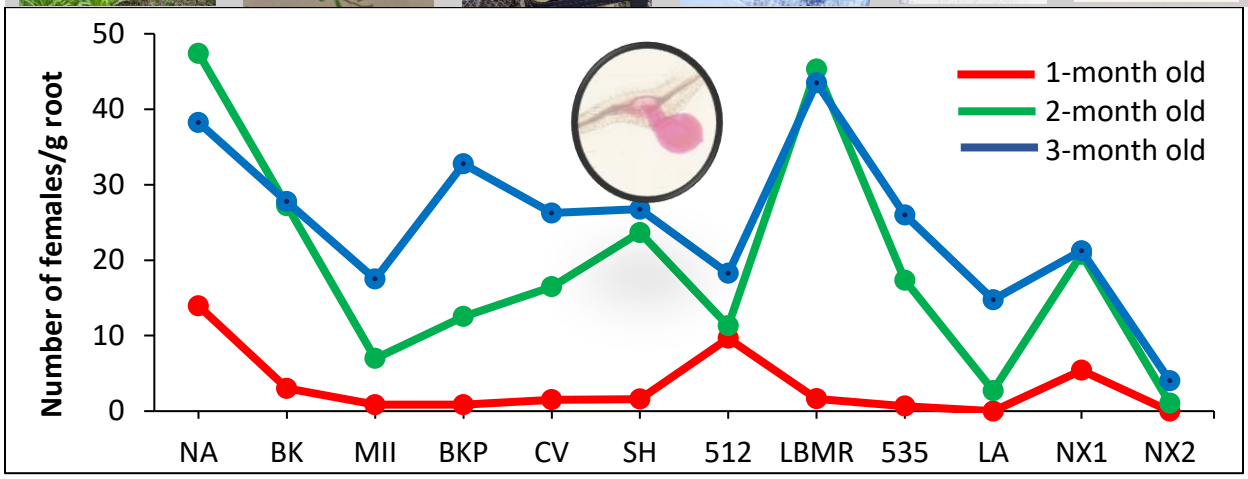
Sunn hemp, *Crotalaria juncea*, has been a popular cover crop in Hawaii for soil health management (Rotar and Joy 1983) due to its ability to generate organic nitrogen source, outcompete weeds, reduce soil erosion, and when plow under, it can suppress key plant-parasitic nematodes in Hawaii such as *Meloidogyne* spp. and *Rotylenchulus reniformis* (Wang et al., 2002). Unfortunately, in the last decade, farmers growing sunn hemp are suffering from *Fusarium* wilt caused by *Fusarium udum* f. sp. *crotalariae* (*Fuc*) (Wang and Dai, 2018) causing the cover crop to die within 30 days after planting. Two viruses, tobacco streak virus (TSV) that causes necrosis and seedling death, and an unclassified tobamovirus that is mechanically transmitted (Kong, 2020), are also now reported in Hawaii. This project aims to examine the use of sorghum for soil health management in Hawaii.

Sorghum, *Sorghum bicolor,* as a cover crop would accumulate more dry biomass, transpire less water, decompose slower, and thus contribute more to soil organic matter as compared to annual leguminous cover crops (Creamer et al. 1996). Moreover, higher soil organic matter contributed from sorghum could also increase soil water holding capacity (Dabney, 1998). This project evaluates performance of different sorghum/sudangrass hybrids for their soil health benefits and plant-parasitic nematode suppressive properties.

Variety	Type	Properties
Bundle King (BK)	Forage sorghum	High yielding, juicy midrib, sterile
Cowvittles (CV)	Forage sorghum	High yielding, juicy midrib
Big Kahuna Plus (BKP)	Forage sorghum	Less lignin, photo sensitive
Monster ll (MII)	Forage sorghum	Photo sensitive, 8-9 ft in height
512×14 (512)	Sorghum-sudangrass hybrid	6-8 ft in height, early maturing
535×14 (535)	Sorghum-sudangrass hybrid	Sterile hybrid, 8-9 ft height
Latte (LA)	Sorghum-sudangrass hybrid	Drought resistant, 7-8 ft height
Latte BMR (LBMR)	Sorghum-sudangrass hybrid	Drought resistant, 7-8 ft height
NX-D-61 (NX2)	Energy sorghum	Large biomass, photo period neutral
NX 4264 (NX1)	Energy sorghum	Large biomass, 15-20 ft in height
Piper	Sudangrass	Annual grass, rapid growth, lower prussic acid content than sorghum-sudangrass

A greenhouse pot trial with sterile sand: soil mix was set up to examine allelopathic effect of sorghum/sorghum-sudangrass hybrids (SSgH) against root-knot nematode (*Meloidogyne incognita*) infection and development to female stage on a susceptible host, kai choi (*Brassica juncea*). Tissues of SSgH were collected from 1-, 2- or 3-month-old field established varieties, chopped and soil incorporated into the sand-soil mix and kai choi seedlings were planted for 1 month prior to root staining.



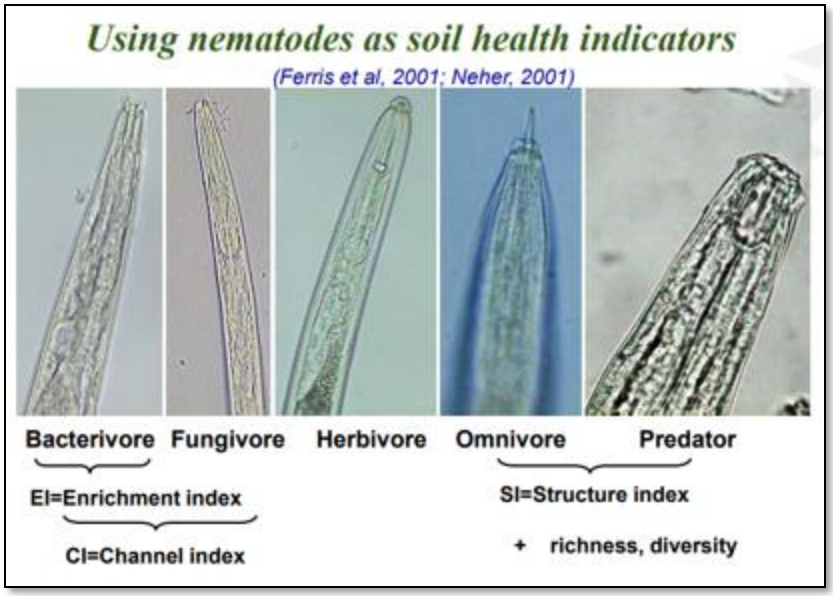


Results from the greenhouse trial showed that allelopathic effects of SSgH against root-knot nematode infection and development into females were different among the varieties and age of the SSgH tested. In most varieties, as the plant aged, their allelopathic effect dissipated (i.e. not different from the non-amended (NA) control), except for NX2 and LA where 3-month old tissue materials were still suppressive to the root-knot nematode. Thus, these two varieties showed good nematode suppressive potential and would be able to grow for 2-3 months to generate sufficient biomass in the field to generate large amounts of organic residues for soil health improvement.

A field trial was conducted at the Poamoho Experiment Station where selected SSgH varieties representing energy, forage sorghum or sorghum-sudangrass hybrids were grown for 2.5 months, terminated using flail mower and eggplant were planted in a minimal tillage practice. Nematode and other soil health related properties data were collected over 5 months of eggplant growth and compared to a bare ground (no SSgH) control.

Summary of data from the SSgH no-till field trial:

1. Energy sorghum, NX1 and NX2 generated the greatest biomass of crop residues (with 'NX2' > 2 times the biomass of 'Bundle King', previously a commonly used forage sorghum for cover cropping in Hawaii).
2. NX2, NX1 and CV significantly increased volumetric soil moisture during the eggplant growth season compared to bare ground (BG) control (with 'NX2' improving soil moisture by 29.7% compared to the BG).
3. 'NX2' was the only variety that resulted in higher soil carbon at termination of the 2.5-month of the cover crop cycle (23.6% increase from BG), though this effect dissipated at the end of the eggplant growing cycle.
4. 'NX2', 'NX1', 'CV' and 'BKP' increased soil microbial respiration rate throughout the cover cropping and eggplant growing cycle, with 'NX2' increasing overall microbial activities by 2 folds.
5. At termination of the cover crop, 'NX2' also increased total microbial biomass measured by phospholipid fatty acid analysis (Microbial ID Lab) by 60%, in particular, 'NX2' increased proportion of non-arbuscular mycorrhizal fungi biomass by 1.9 folds and eukaryotic biomass by 2.7 folds compared to BG.
6. At 3 months after planting of eggplant, microbial biomass of eggplant rhizosphere in 'LA' plots became most improved in 'LA' with 87.1% increased from BG.
7. Unfortunately, eggplant yields over the 5 months were not different among treatments in part due to thrips and mites infestation as well as heavy root-knot infection. Root-knot nematode population densities in the soil were suppressed by CV and 512 up to 2 months after eggplant transplanting, but not thereafter.



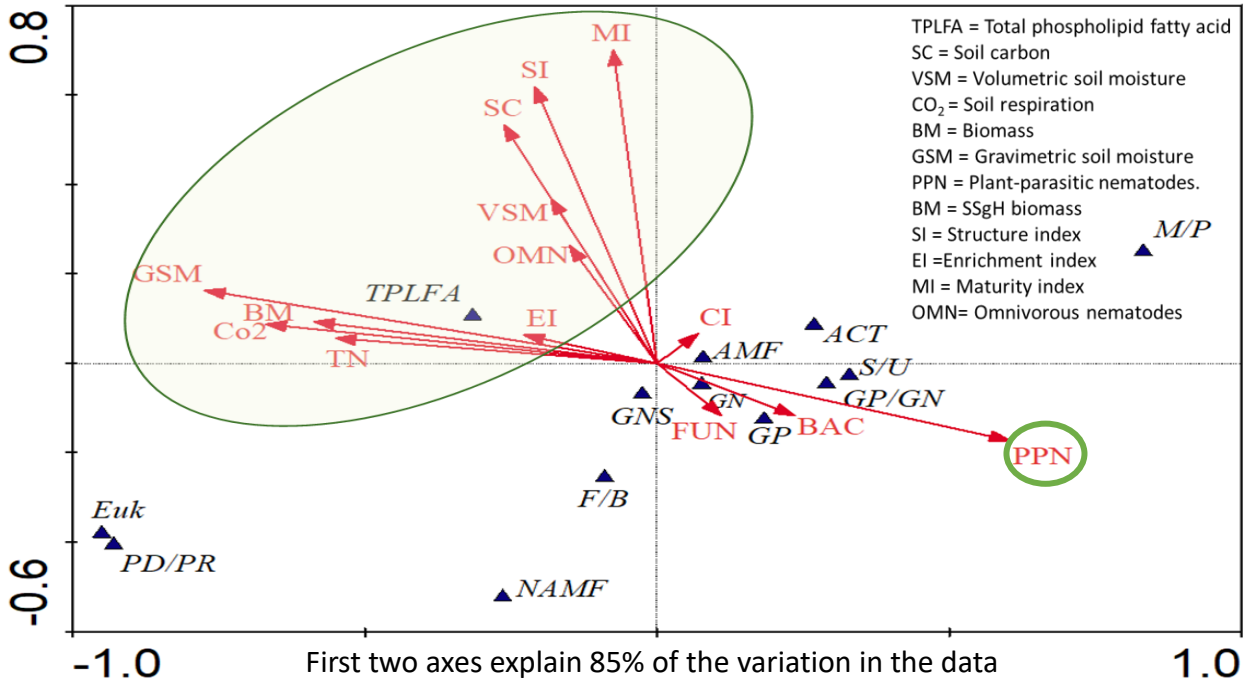
More bacterivorous nematodes means more bacterial decomposition. More fungivores means more fungal decomposition. Abundant omnivorous and predatory nematodes means soil is not being disturbed and soil food web is structured.

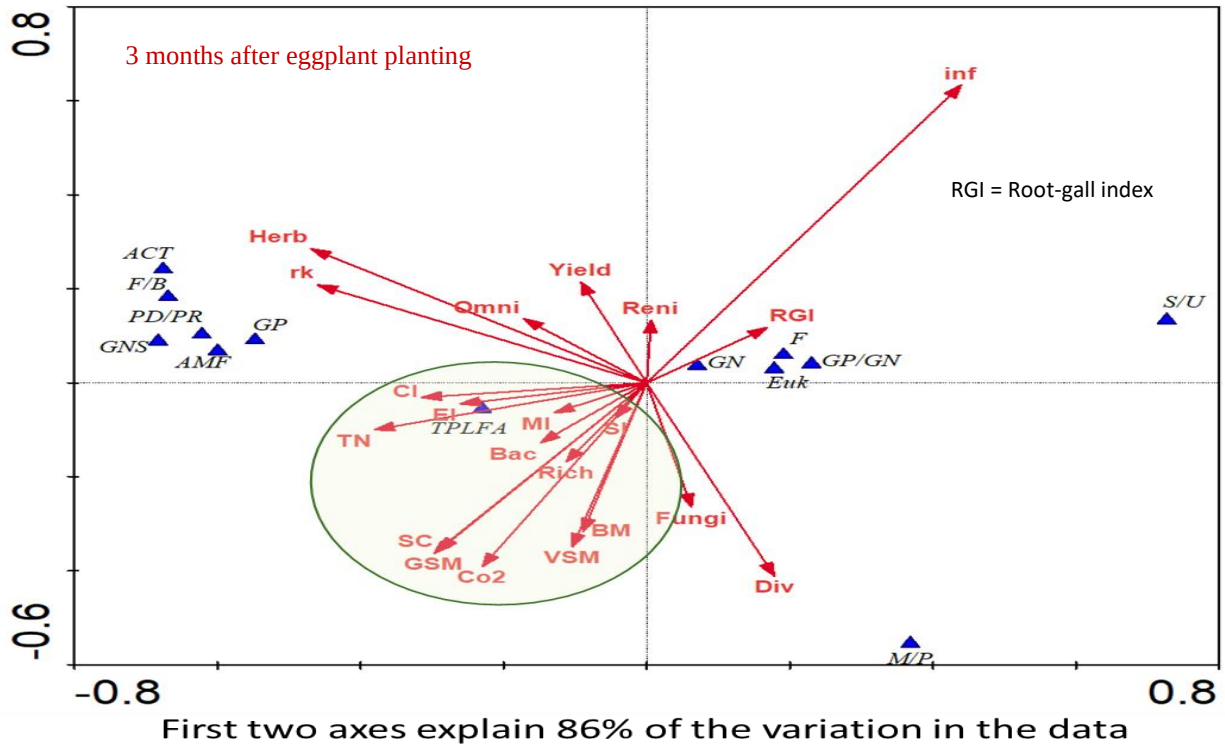
High Enrichment Index (EI) means more opportunistic bacterial feeding nematodes, which is often related to more nutrient enrichment.

High in Channel Index indicates soil is dominated by fungal decomposition, less bacterial decomposition. This could mean either the soil is stressed or go into the succession of decomposition. When the Structure Index (SI) is high it means soil is less disturbed.

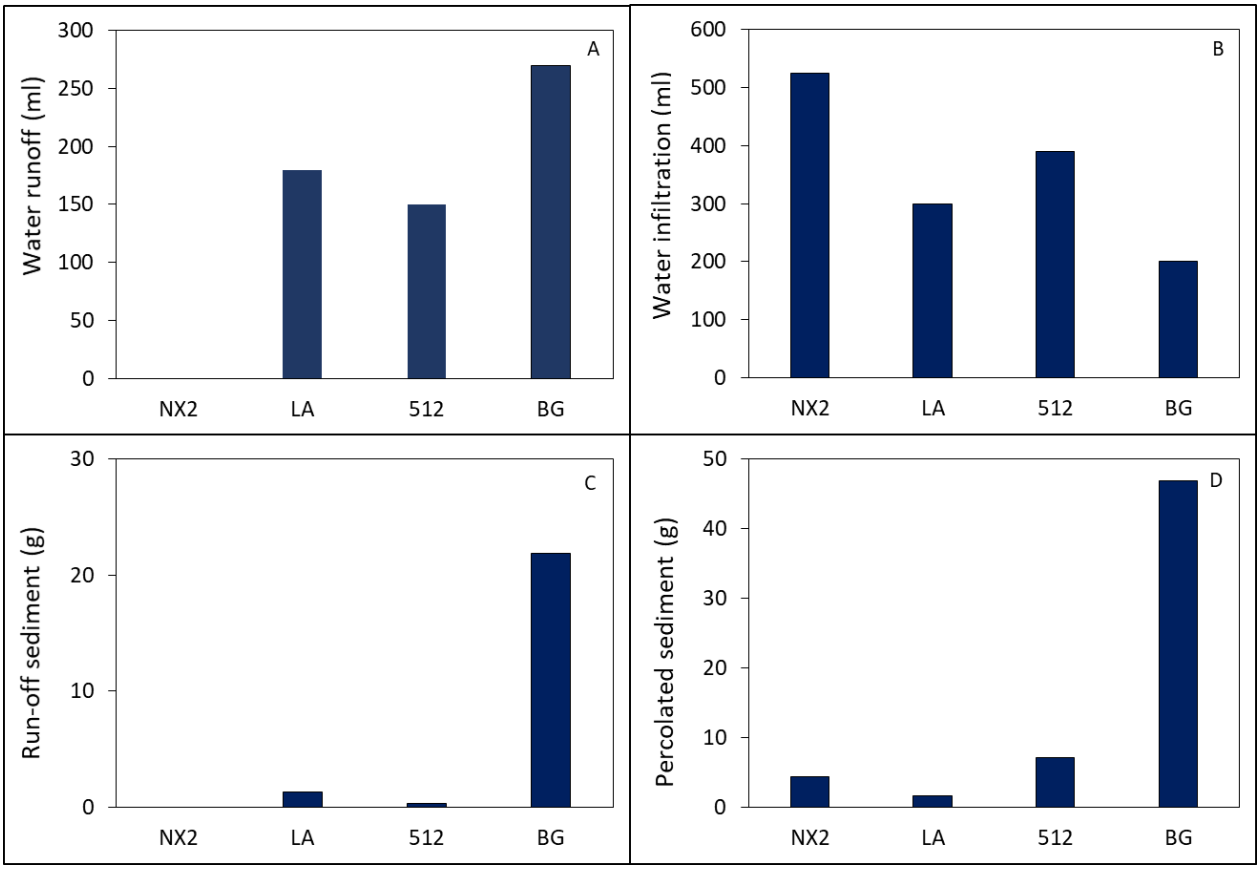
Richness is a calculation of nematode total genera or taxa; where Simpson Index of Diversity is used here to calculate diversity of nematode fauna.

At termination of the SSgH cover cropping period, most of the soil health indicators (Total PLFA which indicates soil microbial biomass, CO_2 which is soil microbial respiration rates, soil moisture, soil C), as well as nematode soil health indicators (EI, MI, SI), and abundance of omnivorous nematodes were negatively related to abundance of plant-parasitic nematodes. Although this effect dissipated **at 3 months after eggplant planting**, negative relationships between root-gall index (caused by root-knot nematodes) on eggplant with the above-mentioned soil health indicators was observed. Thus, these results suggested improvement of soil health by SSgH led to suppression of root-knot nematode infection on the cash crop in a no-till system.





Soil blocks were collected from representative plots of NX2, 512, LA and the bare ground control at 2 months after termination of the eggplant crop from this experiment. A simulation rainfall demonstration was performed by pouring over 660 ml of "rainwater" over the demonstration kits. Water runoff or infiltrated through the soil blocks were collected and soil sediments associated were weighed. Video: https://www.youtube.com/watch?v=hbCSWttx8_A



Soil from the **NX2 (=NX-D-61**) plot resulted in no runoff and highest water infiltration (A, B) whereas soil in the bare ground (BG) control had highest water runoff, along with soil sediment runoff, and least water infiltrated into the soil (A-C). This is all due to the high amount of organic residues from growing NX2 sorghum cover crop that stimulated active microbial activities. Accumulation of microbial biomass could increase soil aggregate stability. NX2 is also shown to suppress root-knot nematodes prior to cash crop planting. Future work is looking into if SSgH cover cropping could suppress *Fuc* infestation and allow sunn hemp to reestablish in *Fuc* infested soil through an improved biofumigation effect.

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This project is supported by NRCS CIG Hawaii NR1992510002G001, CTAHR Hatch, Multistate and Plant of Work (HAW9048-H, 9034-R and POW 16-964), and WSARE graduate student grant GW20-212. The author would like to thank Donna Meyer, Sabina Budhathoki, and Justin Mew for their technical assistance.