Use of Korean Natural Farming for Vegetable Crop Production in Hawai'i

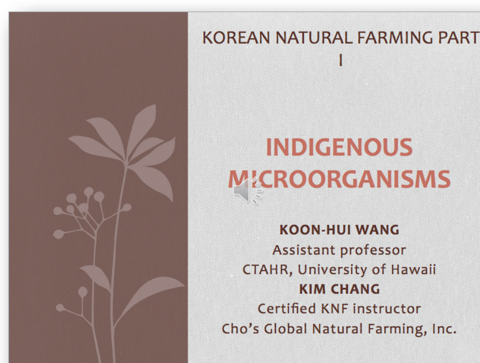
Koon-Hui Wang (CTAHR), Mike DuPonte (CTAHR), Kim Chang (Cho's Global Natural Farming)

Introduction

Korean Natural Farming (KNF) involves collecting and culturing indigenous microorganisms (IMO) and reintroducing them into an agro ecosystem, which has been managed by people. Nutrients from various composts are applied to a plant using a foliar spray to minimize the use of off-farm inputs (Park and DuPonte, 2008). This farming approach has been extensively promoted by Han-Kyu Cho and his followers (Cho and Cho, 2010; Drake, 2012). This farming approach maximizes the use of on-farm resources, recycles farm waste, and minimizes external inputs while fostering soil health and is gaining popularity among farmers in Hawai'i that are interested in sustainable agriculture. KNF has been practiced for decades in Asia and was introduced to Hawai'i in 1999 (http://www.thainaturalfarming.com/), and has been adopted by several farmers in Hawai'i. However, scientific evidence of the benefits of KNF has been limited. This article will provide links to information about: 1) the basic procedure to cultivate IMO and apply this compost, 2) preparation of foliar sprays used in KNF practice, and 3) will summarize results from three field trials that compared KNF to conventional farming that uses synthetic chemicals or to organic farming.

Indigenous Microorganisms

The basic principle behind natural farming is to create a farming environment compatible with naturally occurring organisms in our farmland. Enhancement of indigenous microorganisms is more likely as compared to introducing alien beneficial organisms. It is important to take note that KNF recommends cultivation of IMO from your own farm. Introducing IMO cultivated from your farm to another region might lead to total failure of KNF. A standardized procedure to prepare IMO for KNF practice has been published by Cho and Cho (2010). A more detailed description on how to make IMO using resources readily available in Hawai'i has been published by Park and DuPonte (2008). A short video clip on how to prepare five types of IMO and apply them in a cropping system can be found at http://www.ctahr.hawaii.edu/WangKH/KNF-V2.html.



Foliar Sprays

Although fertilization through soil feeding is a normal farming practice, it limits the availability of nutrients to the plant. Some nutrients such as phosphorus (P), potassium (K), and micronutrients bind with the soil complex easily, making them unavailable for the plant. More soluble nutrients, such as nitrogen (N), are easily leached down to the soil, and end up polluting the groundwater and aquifer. With the increasing prices of fossil fuel, the cost of synthetic fertilizer continues to increase and farmers across the State are looking for affordable fertilizer (Parcon et al., 2011).

Korean Natural Farming recycles nutrients from various herbs or farm waste, and combines them into a foliar spray for fertilization based on growth stages of the crop. A recent article in Critical Review of Plant Science stated that foliar fertilization is an agricultural method of increasing importance in practical terms (Fernández and Eichert, 2009). The application of nutrient sprays may indeed be environmentally friendly since the nutrients are directly delivered to the plant in limited amounts. Additional advantages of using foliar KNF inputs include benefits to young seedlings with smaller root systems, reductions in the amount of N application, better nutrient uptake during reproductive stage due to a decrease in root activity, and the ability to modify the nutrient inputs accordingly. However, the effect of foliar nutrient application could vary based on the plant's growth conditions.

A short video clip that briefly overviews the preparation of some key nutrients and the mixing of various KNF inputs for different growth stages can be found at http://www.ctahr.hawaii.edu/WangKH/KNF-V3.html. For more details on how to prepare KNF inputs, instruction from Cho's Global Natural Farming (CGNF) certified instructors is recommended. Good sanitation practices are advised while preparing KNF inputs due to food safety concerns. Initial testing on KNF inputs such as water soluble calcium (WCA) and fish amino acid (FAA) prepared by certified CGNF instructors tested negative for Salmonella (Food Quality Lab, Honolulu, HI). However, the concentrate form of WCA and lactic acid bacteria (LAB) tested positive for egg and milk allergens, respectively. The allergen test result is expected as these materials are prepared from eggshell and milk. Thus, produce sprayed with KNF inputs may need to be labeled as a potential source of egg and milk allergens. However, when FAA and WCA were diluted into KNF foliar sprays, neither allergens could be detected. More tests need to be conducted on various diluted forms of KNF sprays.

Fig. 1. Experiment at Farm 1: soybean growth in A) Korean Natural Farming (KNF) practice, and B) conventional (CONV) farming practice.

Comparing KNF with other cultural practices

Three farmers completed in-field evaluations of KNF for vegetable or row crops individually in the Pahoa Area in Hawai'i from December, 2011 to May, 2012. All farms used KNF practices and compared them to another type of farming of their choice. Conventional farming involved the use of synthetic fertilizer and pesticides, and organic farming involved the use of organic fertilizer and pesticides.

Each of the farmers modified their KNF practices based on resources available and the soil type they had on their farm. In general, all of these farms have Keaukaha soil which is composed mainly of Pāhoehoe lava that is extremely rocky. Thus, all of them transported topsoil from soil companies or elsewhere. Farmer 1 grew soybeans, Farmer 2 grew multiple vegetable crops including kale, beets, broccoli, onions and leeks, and Farmer 3 grew kabocha squash. Since KNF requires soil mulching, these farmers used different types of mulch based on their convenience. Farmer 1 used sunn hemp (*Crotalaria juncea*) as pre-plant cover crop followed by mowing down as surface mulch, Farmer 2 used macadamia nut husk from a nearby macadamia nut farm, and Farmer 3 purchased shredded wood chips as mulch. Farmers 1 and 3 compared KNF to conventional farming, whereas Farmer 2 compared it to their standard practice of organic permaculture. Their organic plots were treated with organic composted chicken manure (Nutrarich Pellets 5-3-2 and 7% Ca). Three types of evaluation were conducted: 1) plant health, 2) soil health analysis, and 3) weed densities measurement.

For plant health, farmers recorded the yield qualitatively or descriptively. At harvest, young fully matured leaves from each treatment plots were measured for their chlorophyll content using a Digital Chlorophyll SPAD meter (Spectrum Technologies, Inc., Plainfield, IL). Leaves were also sampled and sent to CTAHR ADSC laboratory to assay for macro- and micro-nutrients.

Fig. 2. Korean Natural Farming (KNF) trial at Farm 2. Crops grown from the front to the back of the rows are leek, burdock, beet, and curly kale.

For soil health, 6 soil cores of approximately 5-cm diameter and 20-cm deep were taken around the root zone of the crops from each treatment plot. Soil was composited, bagged, and brought into the laboratory. Subsamples of 250 cm^3 were taken from each soil sample and extracted for nematodes using an elutriator. All nematodes extracted were identified to the genus level, counted, and catagorized into trophic groups for their functional analysis. In addition, three nematode community indices were calculated to understand the soil health conditions. These indices were the Enrichment Index (EI) that assesses food web responses to available nutrient resources, the

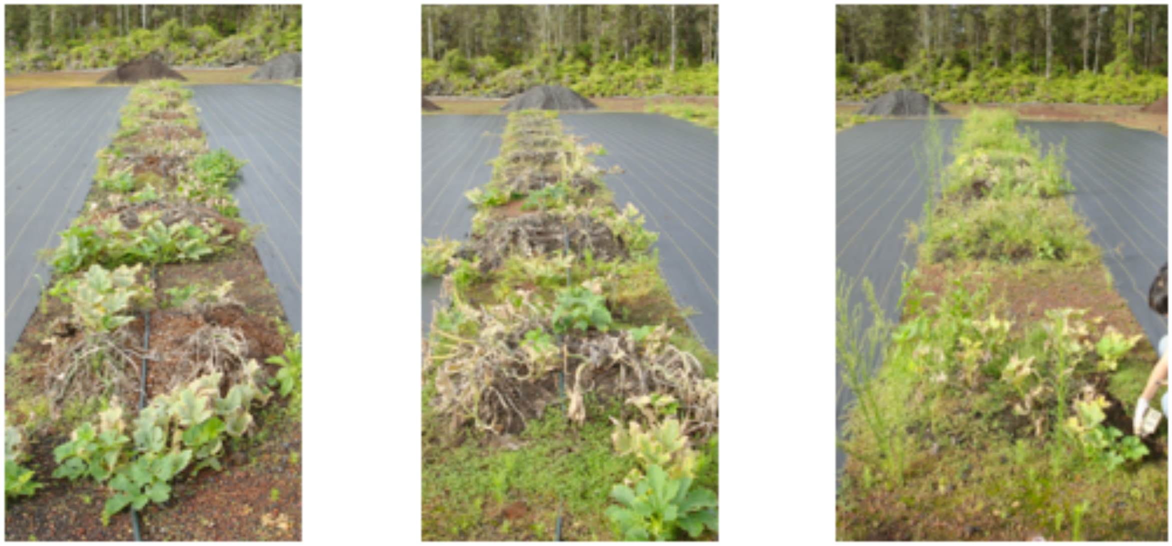
Table 1. Comparing plant and soil health measurements between conventional farming (CONV) and Korean Natural Farming (KNF) practices on soybean in Farm 1, burdock and leek in Farm 2, and kabocha squash in Farm 3.

	Farm 1 (Soybean)		Farm 2 (Burdock)		Farm 2(Leek)		Farm 3 (Kabocha)	
	CONV	KNF	Org	KNF	Org	KNF	CONV	KNF
Plant Health Analysis								
Yield (kg)	25.08	32.23	-	-	-	-	31.78	23.15
Leaf weight (5 leaves, g)	1.37	2.49 **	5.70	8.52	1.59	3.49@	1.76	1.76
Chlorophyll content	25.52	37.27 **	31.9	36.14 *	52.78	55.2	26.84	32.93 **
N (%)	3.69	5.38 *	3.90	4.45@	3.30	4.01@	4.97	5.21
P (%)	0.30	0.38@	0.59	0.71	0.55	0.61	1.28	1.03
K (%)	2.35	2.41	4.51	6.03*	3.90	3.00	3.68	3.69
Ca (%)	1.03	1.01	1.15	0.38	0.74	0.80	1.58	0.84*
Mg (%)	0.45	0.42	0.36	0.32	0.32	0.38*	0.80	0.49*
Na (%)	0.05	0.03 *	0.04	0.05	0.06	0.13**	0.06	0.05
Fe (ppm)	88	91.75	84	123.00@	79.00	82.33	69	76
Mn (ppm)	61.67	62.75	17.33	24.67*	18	21.67	31.67	44.33
Zn (ppm)	62.33	53.50	36	39	67.33	58.33	102	80
Cu (ppm)	9	9	8.67	12.00	10	9.33	19	12
Bo (ppm)	37.67	40.50	40.67	31.33**	39.00	38.33	43.67	34
Soil Health Indicators								
Enchytraeid worm'	3	33	7	0	0	0	0	157 **
Nematodes'								
Bacterivores	153	320	123	780	127	127	1813	1470
Fungivores	163	300	30	360	23	133@	23	50
Herbivores	20	0	140	303	267	577	0	0
Omnivores	3	27 **	57	53	0	20	157	127
Predators	0	40 **	0	0	0	0	0	0
richness	8	15 **	8	15	7	10	12	9
Diversity	3.43	5.86	4.05	4.80	3.78	4.00	3.68	2.57
EI	39.39	39.58	92.87	73.70	86.52	74.42	92.05	97.45
SI	12.13	55.70 *	85.92	49.93	78.41	54.36	66.28	82.14
CI	87.00	82.00	6.11	28.51	11.89	26.36	0.63	1.57
Soil depth	17.48	22.86**	11.00	17.8**	13.20	17.00*	-	-
Over all did KNF improve plant and soil health?	YES		Plant health: Yes Soil health: No		Plant health: Yes Soil health: NS[y]		Plant health: No, nut greener Soil health: slightly, NS	

' Numbers in 250 cm^3 soil.

[y] NS=Not significant.

@, *, and ** indicate significant difference between CONV and KNF based on one-way analysis of variance at P < 0.10, 0.05, and 0.010 level, respectively.



Korean Natural Farming Conventional Untreated Control

Fig. 3. Weed densities at termination of kabocha trial at Farm 3.

Structure Index (SI) that reflects the increasing complexity of the soil food web as the system matures, and the Channel Index (CI) that reflects the decomposition pathway in the soil food web (Ferris et al., 2001). In general, higher EI and lower CI suggests greater bacterial activity, more nutrient enrichment, whereas higher SI indicates a soil is less disturbed. To further evaluate if KNF practice could improve soil physical structure as claimed by Master Cho, soil compaction was measured using a Soil Compaction Tester (Spectrum, Inc.).

Weed densities were recorded at the end of cropping season using a Horsfall and Barrett (1945) scale where 1 = 0%, 2 = 0-3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50% of ground covered, 7 = 25-50%, 8 = 12-25%, 9 = 6-12%, 10 = 3-6%, 11 = 0-3%, and 12 = 0% of ground not covered.

Table 2. Weed densities at the end of one cash crop cycle in Korean Natural Farming vs conventional farming at Farm 3.

Farming Practices	Weed densities (H-B Scale) [z]
Untreated control (no herbicide)	7.30 a [y]
Conventional (with herbicide)	4.20 b
KNF	4.10 b

[z] Horsfall-Barrett (H-B) Scale of 1-12, where 1 = no weed, 12 = 100 % weed coverage.

[y] Means followed by the same letter indicate no difference among farming practices based on one-way analysis of variance at $P < 0.05$ level.

Summary of results

In general, KNF did significantly improve plant health for some of the variables (Table 1, Fig. 1). The effect was most significant for the soybean trial.

Heavy rains presented challenges at Farm 2 and more seedlings died back in the KNF plots. In addition, since Farm 2 was an organic operation, a higher standard for KNF to meet was already in place. However, when Farmer 2 incorporated animal manure in the IMO compost (i.e. IMO5), the plants responded positively and resulted in better growth at harvest.

Heavy infestation of powdery mildew, fruit fly and pickle worm on kabocha on Farm 3 (Fig. 2) interfered with the evaluation of KNF. KNF does not protect plants from diseases and insects, and thus is not effective in heavy rainfall. Shelter may be needed by plants in wet areas. KNF required less irrigation than conventional farming. Future research should examine integrating of KNF with other pest management strategies.

Results also indicated that mulching as recommended in KNF significantly reduced weed pressure, eliminating the need for further weed management (Table 2). KNF also enhanced earthworm or enchytraeid worm activities (Table 1). More data on mycorrhizae colonization is needed. Earthworm and mycorrhizae could be contributing to increases in soil tilth in KNF plots (Table 1). Integration of sunn hemp cover cropping prior to KNF might have resulted in significant improvement of soil health condition in KNF plots at Farm 1 (Table 1).

Soil analysis of Farm 1 revealed that KNF at pre-soybean planting increased soil P and K, and reduced the recommended application rate of gypsum and Mg-sulphate. Farmer 1 commented that reducing the use of gypsum is a large benefit to growers because of its high cost relative to other fertilizers.

Overall, KNF practice improved plant and soil health conditions in two out of the three trials, but it consistently improved soil tilth. Adding animal manure to IMO out performed IMO without manure. This project clearly indicated that when KNF is performing well, it enhanced free-living nematodes that play key roles in soil nutrient cycling and increased abundance of other soil fauna such as enchytraeid worms that improve soil tilth. More research is needed on understanding functions of the other indigenous microorganisms that might have contributed to the benefits of KNF.

Additional web resources about KNF in Hawaii

- Hawaiian Homegrown Food Network: http://hawaiihomegrown.net/reports/97-natural-farming-primer
- Richard Ha: http://hahaha.hamakuasprings.com/
- Drake Weinert: http://naturalfarminghawaii.net/
- Jackie Prell: http://www.acresusa.com/toolbox/reprints/Jan10_Prell.pdf
- Honolulu Star Bulletin: http://www.staradvertiser.com/news/20110118_Natural_selection.html?id=114074644

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Sugarcane and taro planted with Korean Natural Farming practice at Onamea Stream, Hawai'i.

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