A Comparison of Organic and Natural Farming practices on Soil Quality and Biodiversity of Soil Invertebrates

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ABSTRACT: There are several different types of farming practices including organic and natural. We compared the effect of organic and natural farming practices on soil quality and biodiversity of invertebrates. Soil was analyzed for nutrient content and soil invertebrates were collected and identified by morphologic characteristics and DNA analyses. Soil from both farms had acceptable pH and high concentrations of phosphorus and potassium. The organic matter content was higher in the soil samples from the natural farm than the organic farm. The number and types of soil invertebrates were higher in the natural farm than in the organic farm. The higher organic matter content in the soil of the natural farm correlated with the higher number and variety of soil invertebrates compared to the organic farm. The natural farm had a higher number and diversity of soil invertebrates than the organic farm, but a similar number of beneficial and harmful invertebrates.

INTRODUCTION: Having grown up on Long Island close to a number of farms we decided to focus our attention on the benefits that soil dwelling invertebrates provide in agroecosystems. Soil dwelling invertebrates are a key component of agricultural landscapes. They participate in essential soil processes that maintain healthy productive soils including soil aeration and control of pests. Reduction in the diversity of soil invertebrates has drastic ecological effects such as long-term deterioration of soil fertility and agricultural productive capacity[1]. Examples of soil dwelling invertebrates include gastropods, spiders, millipedes, woodlice, ants, ground beetles and rove beetles and arthropods are worms, ants, bugs, beetles. Winter invertebrates include worms, snails and spiders while other insects migrate or become dormant (diapause).

After researching types of farms and visiting several farms on Long Island, we learned that there are traditional farms that use pesticides and fertilizers as well as organic and natural farms that do not use pesticides or artificial fertilizers. In Europe, the application of pesticides which are groups of chemicals that are toxic to insects and other arthropods, has been shown to have a negative impact on various components of biodiversity[2]. We chose to study the differences between natural farms and organic farms. Organic farms are those that do not use pesticides or synthetic fertilizers but they add external organic materials such as compost and cow dung manure as fertilizers. Natural farming practices are environmentally regenerative in which neither chemicals nor organic fertilizers are added and the soil is not tilled[3].

The aim of chemical free farms is to maintain high quality chemical free soil which will positively impact both biodiversity and number of organisms in the soil and air.
Three important differences between natural farming & organic farming[4]:

1) Cost: Organic farming is more expensive than natural farming because it requires using large amounts of organic fertilizers & manure on the land bought from those who sell them.
2) Effort: Organic farming requires activities such as mixing of manures or compost, plowing, and tilting whereas there is no plowing or tilting or fertilizers in natural farming. "In natural farming, decomposition of organic matter by microbes & earthworms is encouraged right on the soil surface itself, which slowly releases nutrients into the soil".
3) Environmental impact: Organic farming has an effect on the surrounding environment while natural farming does not & it conforms with local biodiversity.

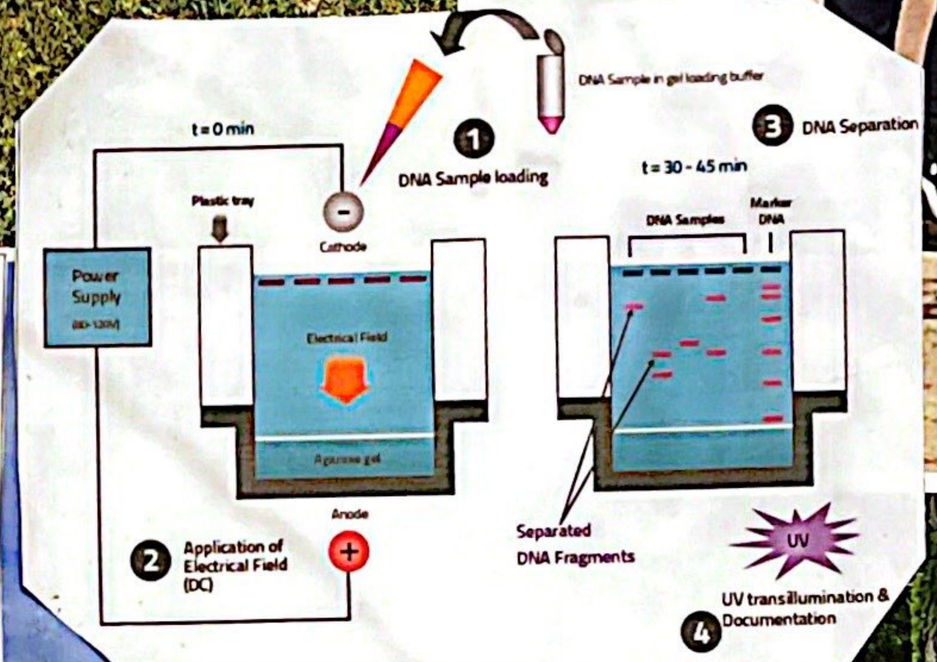
We plan to determine if there are differences in soil quality between organic farms and natural farms and with different types of crops. In addition, we plan to determine if the number and types of invertebrates vary with farm type and crops that are planted. We hypothesize that the number and diversity of soil and air invertebrates will be higher in soil collected from the natural farm. We also hypothesize that the measures of soil quality will be higher in soil collected from natural farm.

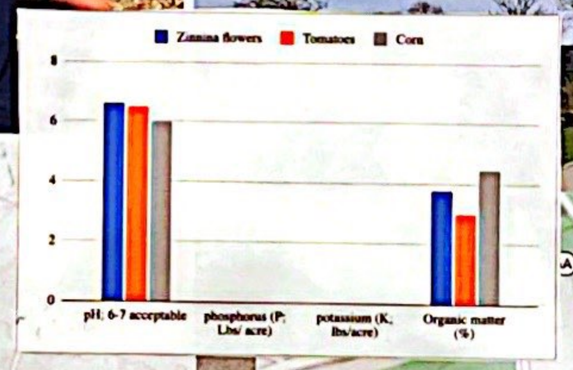
MATERIALS AND METHODS: We obtained soil samples and invertebrate organisms from farms that were natural or organic. We received permission to obtain soil samples and collect invertebrates from two farms in Nassau County, Long Island: one was a natural farm and one organic farm. At each farm we obtained soil samples from two different fields that produce different crops. We selected fields that were in open spaces with minimal human activity because human activity can compress the soil and may affect invertebrate number and biodiversity. We recorded the location of the fields as well as the crops grown in these fields. The soil samples were saved in zip-lock plastic storage bags. The soil samples were analyzed at the Cornell Cooperative extension of Nassau County, East Meadow, NY. The nutrient analysis provides a measure of soil quality and included testing pH, potassium, phosphorus, and percent of organic matter, a measure of nitrogen content.

We collected invertebrates, specifically arachnids and insects, from the soil using soil sifters and from the air above the fields using butterfly nets. For each invertebrate we recorded the number, location, and date of collection. Specimens were transported to the DNA Learning Center where we took a high quality microscope photograph and identified the invertebrates and obtain specimens for DNA analysis. We used the CHELEX method of DNA extraction that is suitable for extracting DNA from small samples. A small piece of the specimen was added to a Chelex solution, pH 10-11 and pipetted and expelled for approximately 3 minutes. The tube was then be incubated in boiling water for 10 minutes to disrupt the cell membrane and cause the double helix DNA to denature. Resin beads bind to the cellular components while RNA and DNA remain dissolved in the aqueous solution. The extracted DNA was subjected to gel electrophoresis and then amplified, sequenced and analyzed for sequence quality. Using a BLAST search the sequences were compared to known sequences of invertebrates to determine the species and the relationship to other species.

Table 1. Results of Soil Analyses

Farm type	Organic	Organic	Natural	Nartural
Soil specimen Number	1	2	3	4
Crop	Zinnina flowers	Tomatoes	Sunflowers	Corn
pH (6-7 acceptable)	6.6	6.5	6.7 (OK)	6
Phosphorus (P; Lbs/ acre	59 (high)	56 (high)	67 (very high)	18 (relatively high)
Potassium (K; lbs/acre)	453 (high)	459 (high)	442 (high)	458 (high)
Organic matter (%)	3.8	3.0	10.1	4.5





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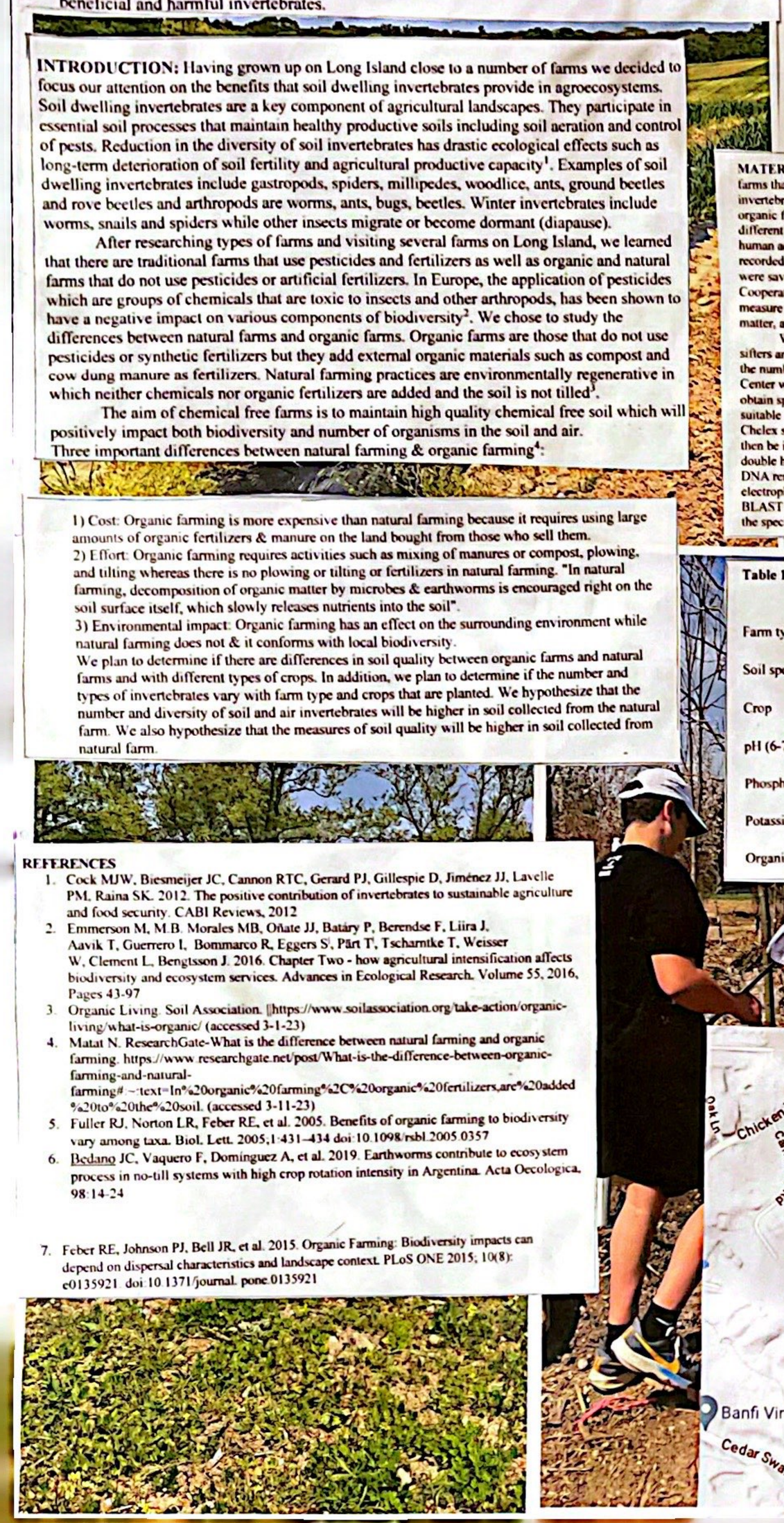


DISCUSSION: The organic matter content of the soil likely contributed to the high levels of phosphorus and potassium in the soil. The organic matter levels in the soil samples from the natural farm were higher than optimal which may be due to the regenerative technique used in the natural farm. The higher organic matter content provides more nitrogen to the soil which is beneficial for soil dwelling organisms.

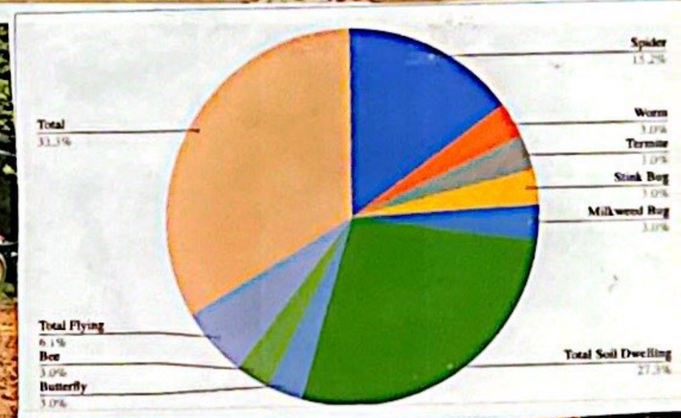
We found a higher biodiversity among soil dwelling (but not flying) invertebrates in natural farms than in organic farms. Separate studies of organic[5] and natural[6] farming practices have found higher number of invertebrates than traditional farming practices using insecticides. We did not identify studies that directly compare the number and biodiversity of invertebrates in organic and natural farming practices. The number of beneficial and predatory species were similar at both farms but our sample size of organisms was relatively small and a larger study might show significant differences. Our data supports a higher biodiversity of soil dwelling invertebrates with natural farming practice than with organic farming practice.

The timing of collection of invertebrate samples can have an impact on biodiversity with more invertebrate organisms and diversity in samples taken while crops are in place. Feber et al found a higher biodiversity of invertebrates in the presence of crops than after harvest.[7] This effect may vary with the type of invertebrate. In our study the collection of invertebrates took place after harvest and may have resulted in a lower number and biodiversity of invertebrate organism than if the study was performed when crops were present.

In conclusion, the natural farm had higher organic matter content and a higher number and diversity of soil dwelling invertebrates than the organic farm, suggesting that natural farms may maintain the ecosystem better than organic farms.

Table 2. Comparison of Soil Dwelling and Flying Invertebrates from a Natural and an Organic Farm

Invertebrate Category	Number Collected and Analyzed	
	Natural	Organic
Soil Dwelling		
Spider	5	1
Worm	1	0
Termite	1	0
Stink Bug	1	2
Milkweed Bug	1	0
Total Soil Dwelling	**9**	**3**
Flying		
Beetle	0	3
Lady Bug	0	1
Fly	0	3
Butterfly	1	4
Bee	1	3
Total Flying	**2**	**14**
Total	**11**	**17**



RESULTS: The results of the soil analyses (Table 1) indicated that samples from each farm had pH readings that were in the acceptable pH range of 6-7. In contrast the phosphorus and potassium concentrations of all samples were high. The organic matter content was higher in the soil samples from the natural farm than the organic farm.

The number and diversity of soil-dwelling invertebrates in the natural farm was greater than in the organic farm (Table 2). Based on DNA analyses or morphologic criteria, we identified 18 invertebrates (Table 3). On each farm there were 4 beneficial and 3 predatory species (Table 3).

Some Key Findings: The Xylocopa Virginicia, commonly know as the carpenter bee, is known to burrow into hard plant material like dead wood. This specimen is beneficial for farming because they break down organic material which contributes to the development of mulch. Both the Eupeodes Americanus and Coccinella Septempunctata, commonly known as the American Hover Fly and Seven spot lady bird are yet another example of specimens within our findings that aids in farming for its ability to kill and control aphids. Additionally the Pardosa Milvina, commonly know as a shore spider benefit in their ability to feed on agricultural pests and scale insets. Yet, this specimen also has the ability to do harm. When found near rivers and agricultural environments its bite might cause allergic reactions to people. However, The Murgantia

Histrionica, also know as the Harlequin Cabbage Bug, has a negative effect on farming due to their ability to successfully feed on the crops like fruits and vegetables in an agricultural environment.