The Productivity of Vegan-Organic Farming

Measuring small-scale vegan-organic farming against large-scale conventional and organic practices

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Report Preamble

The present document is meant to show how small-scale vegan-organic agriculture compares to conventional and organic agriculture in the United States. To make the comparison this report utilizes data from La Ferme de l'Aube, a small-scale vegan-organic farm that operated during the 2018 growing season.

Bias

There is an ethical obligation to disclose the bias of the preparers and analyzers involved in this report. The Humane Party aims and fights to free all animals from abuse, exploitation, and property status. It is in the Humane Party's interest that the results of this report support its goal insofar as possible. All members involved in this investigation, analysis, and report have acted at the margins of this bias, striving for their judgment to remain unaffected by said bias.

Sources

The sources used for this report include data from The USDA Economic Research Service, National Agricultural Statistics Service, Environmental Protection Agency, Food and Agricultural Organization of the UN, academic journal articles and trade organization data.

Keywords

United States, Agriculture, Vegan

Introduction

Is it possible that small farms are the answer to feeding the world most productively?

Let us consider:

Small farms measuring less than 2 hectares (a little less than 5 acres) constitute 85% of the total operated farms in the world. The overwhelming majority of these small farms are located in Asia (87%). The average farm size in Asia and Africa is 1.6 hectares (about 4 acres). In contrast, the average farm size in Europe is 27 hectares, Latin America 67 hectares and North America (Canada and the United States) 121 hectares. Various studies in India in the 60's, 70's and later years have revealed that there is an inverse relationship between size of farms and productivity, despite a few researchers holding contrary opinions. Findings by UN Agencies and National Sample Survey (NSS) have supported farm size and productivity relationship (Kadapotti & Bagalkoti, 2014). (1)

In the essay, "Productivity, Technical Efficiency and Farm Size in Paraguyan Agriculture," the author concludes that, "the relationship between productivity and farm size is an affirmation of the inverse relationship in the case of Paraguay … land productivity is significantly greater for smaller farms (especially the very smallest farms)." (2)

In the working paper, "Brazil's Agricultural Total Factor Productivity Growth by Farm Size," the author shows that, "The farm sizes achieving, over the 1985–2006 period (in Brazil), the fastest annual total factor productivity (TFP) growth were the smallest (0–5 ha) and largest (500+ ha), the former having a small growth advantage. Farmers operating less than 5 hectares also achieved the fastest rate of technical change. The slowest TFP growth rate, in the national analysis, was experienced by the 20–100 ha size class, followed by the 100–500 ha class." (3)

The article, "Inverse Productivity or Inverse Efficiency? Evidence from Mexico" (Kagin et al. 2016) confirms "the existence of both an inverse productivity and inverse efficiency relationship in rural Mexico … small farms have more output value per hectare and operate closer to their efficiency frontier than large farms. Overall our findings offer a guardedly optimistic view of small farms' capacity to produce efficiently…" (4)

The Food and Agriculture Organization of the United Nations, "State of Food and Agriculture Report 2014," shows that, "families run nine out of every ten farms (worldwide) or 500 million farms. Additional analysis shows that family farms occupy a large share of the world's agricultural land and produce about 80% of the world's food." Furthermore, the report states that, "worldwide farms of less than 5 hectares account for 94% of all farms and occupy only 19% of all farmland … and smaller farms tend to have higher yields than larger farms within the same country." (5, 6)

The European Union has been taking notice of the presence of small farms. The article "Typology and distribution of small farms in Europe: Towards a better picture" (Guiomar et al 2016), states that, "The contribution of small farms to local food supply, food security and food sovereignty is widely acknowledged at a global level. In the particular case of Europe, they are often seen as an alternative to large and specialized farms. Assessing the real role of small farms has been limited by a lack of information, as small farms are frequently omitted from agricultural censuses and national statistics." (7)

The United States, however, continues to see its average farm size increase to 180 hectares per farm in 2017. (8) And Canada saw its average farm size grow to 332 hectares in 2016. (9)

To further understand agriculture world-wide and specifically North American (United States and Canada) agriculture, we must look at definitions of the planting methods.

Understanding the Planting Methods

Conventional

This method constitutes 99.6% of all acreage of crops and animals raised in the United States and 98.5% of all acreage of crops and animals raised in Canada; 98.5% of all value/sales at the farm gate in the United States and 98.3% in Canada. (1, 2)

No certification is necessary for operating a conventional farm.

Conventional methods utilize any and all forms of fertilizers, pesticides, herbicides and fungicides, whether derived from chemicals, plants, or animal-based sources.

There are no limits to plowing and/or to proximity to waterways.

Organic

This method constitutes .4% of all acreage of crops and animals raised in the United States and 1.5% of all acreage of crops and animals raised in Canada. 1.5% of all value/sales at the farm gate in the United States and 1.7% in Canada are attributed to organic agriculture. (3, 4)

To be certified USDA organic requires a third-party inspection. Annual documentation and fees are required from the producer. United States organic methods follow the standards put forth by the USDA Organic Program. (5) The standards require the producer to utilize approved-only fertilizers, pesticides, herbicides, fungicides and seeds (cannot use genetically modified organisms—GMOs—or chemically treated seeds).

Most of the products used in growing crops are derived from animal manures, slaughterhouse by-products, fish, bacteria, and plants. The manures, slaughterhouse by-products and fish do not need to be from organically raised animals.

There are no measurable limits to plowing, but there are restrictions on proximity to waterways.

Vegan-organic

This method encompasses a grand total of 14 farms in the United States and 17 in Canada. (6)

The vegan-organic method requires organic certification + additional documentation with a vegan-organic (stock free) certifier. (7) Currently there is only one agency in the United Kingdom certifying vegan-organic farms. In addition to the documentation, there is a yearly grower-to-grower certification, presented to someone who is knowledgeable in vegan-organic practices.

In addition to the organic standards, the vegan-organic standards eliminate the use of all animal-based inputs, in essence growing plants with plants.

There are restrictions on when and how often one can plow as well as requirements for safeguarding waterways and wildlife corridors.

The farmers of the United States have increased agricultural technology over the years and have consolidated farms believing that this is the most efficient way to produce fruits and vegetables. All large-scale farms are worked with tractors. Most of all field preparation, planting, cultivating, weeding and harvesting in conventional farming is done by machine with a multitude of different tractor attachments. Multiple acres are planted with one crop such as cabbages or carrots or hundreds of acres with crops such as dry beans and soybeans and are spaced according to how the tractor can function. The tractor requires enough path space for its large tires and enough room in the beds to pass a planter, weeder and harvester.

Organic systems use this system, but instead of multiple acres it is maybe one- or one-half acre per crop, though still in rows long and wide enough to allow the tractor to pass. In both systems all beds are remade every year with the use of a bed maker. Fertilizers are applied to the whole field even where the eventual tractor tire or walking paths will be.

Some organic systems use a hand model. These systems are similar to a vegan-organic system. However, most organic systems still incorporate the use of a large BCS type rototiller to prepare almost every bed and utilize cultivator attachments. As stated above, the organic system utilizes animal by-products, specifically chicken and cattle manure, for their primary source of fertilization. Like vegan-organic systems, these tractor-less farms are rare.

To better understand the process by which vegan-organic farms operate, we followed a farm for the 2018 growing season.

Key Findings

- La Ferme de l'Aube vegan-organic farm was **2.3% more** productive than conventional and **41.6% more** productive than organic farming methods.
- La Ferme de l'Aube vegan-organic farm generated **868% more** income than conventional and **421% more** income than organic agriculture practices per kilogram of produce.
- La Ferme de l'Aube vegan-organic farm was 33.5% more productive than conventional and 85% more productive than organic farming methods when on-farm waste is considered.

The Vegan-organic Farm Model

La Ferme de l'Aube rests in Boileau, Québec, Canada (45.944837N, -74.805983 W). The farm is certified organic with Ecocert and certified vegan-organic with Stockfree Organic Services. The property was originally purchased in October 2014 by the current owners. The hardiness zone of the farm site is a 3b, which correlates to the lowest temperatures of the winter (-34 C to -37 C). Average freeze dates are: last freeze in the spring average May 21–30; first freeze in the fall September 11–20. The average frost-free growing season is 105–122 days. The farm site is situated on a space of less than 1 acre (.41 hectare), where the top 12 inches of topsoil had been previously scraped off, leaving most of the area devoid of diverse plant life. The fields had never been cultivated prior to the creation of La Ferme de l'Aube.

Methodology of Planting

The initial preparation of the fields was as follows for 2015–2017:

A 50’ x 50’ x 6mm black plastic was laid to begin the composting of any sparse native fauna in the beds. After four weeks the plastic was removed and a 5hp craftsman front-tine rototiller was passed to incorporate the decayed humus and break open the new soil. Beds were staked out at 2.5’ x 50’ and paths at 15”. The soil from the paths was dug with a shovel and placed on the beds. A cover crop of oats was immediately planted. When the cover crop reached appropriate height, it was cut with walking garden shears and four wheelbarrows of vegan-organic compost (a mixture of composted green grass and chipped branch wood) was spread per bed. The cover crop would grow back and would freeze covering the beds for the winter. The beds were created starting in 2015 and continued throughout 2017. Rotations of cover crops were planted after the oats, utilizing annual clover and buckwheat, depending on the crop to be planted after.

2017 was the first year when vegetables were produced for sale on an area of about 2/5ths of an acre (.16 hectare). The 2018 production year saw the area increased to 5/8ths of an acre (.25 hectare). La Ferme de l’Aube grew over 60 different vegetables, fruits and herbs which included over 200 different varieties. Total production for the year was 2,360 kg (5,192 lbs.)

All plants that required transplanting were seeded in the greenhouse at the appropriate times, as described later in the crop sections. All seeding and potting soil was a vegan-organic mix prepared on the farm. It consisted of:

20L of peat moss
1/2 cup of lime

mixed
4 cups of perlite
3 cups of vermiculite
1/3 cup granular algae
1/3 cup soft rock phosphate

watered in and mixed
10 L premier potting mix (peat, perlite, forest humus and lime)
5 L farm prepared compost
1/4 cup mycchorizae
1/4 cup alfalfa meal
1/4 cup soybean meal

All direct seeded crops were seeded directly into the field in succession and at appropriate times.

The field beds were all prepared the same way in the spring of 2018 (except potatoes). The permanent 50 feet by 2.5 feet beds (125 sq. feet) were worked with a 3-pronged hand cultivator and passed with a broadfork. 1–2 lbs. of wood ash were spread to increase the alkalinity of the soil, as soil tests had revealed a pH range of 5.2-5.5, very acidic for the growing of most vegetable and fruit crops. On average, three full wheelbarrows of compost were applied and raked directly onto the beds.

Since potatoes do not mind an acidic soil, no wood ash or compost was brought in prior to planting.

After planting of transplants, a nettle and comfrey tea was sprayed as a liquid plant-based fertilizer every two weeks until plants set fruits or heads bulbed. Upon emergence of potatoes and beans, after about 4 weeks of growth, one spraying was applied. Nettle and comfrey tea was not sprayed on lettuces or kale.

Irrigation was applied as necessary with overhead sprinkler systems for all crops except tomatoes, which utilized drip tape irrigation. Most of the water was collected from rainwater run-off. Some water was used from the on-site surface well when the 115,000-liter rainwater fed pond was empty.

No pesticides, herbicides or fungicides were used.

Weeding was done by hand with the use of a three-prong cultivator, hand hoe, standing hula hoe or wheel hoe as necessary, roughly every two weeks.

Problematic insects were controlled using an insect screen. Colorado Potato Beetles were removed by hand from potatoes as the larvae can defoliate a plant in as little as three days. Onion maggots were removed as they will burrow a hole in the most tender shoot and eat down into the onion itself, rotting the bulb.

Cabbage worms were removed, when the plants were not protected by the insect screen, as they will eat much of the foliage and make the crop unsaleable and deformed.

At harvest all crops were brought in, weighed and written in a log and transcribed into an excel spreadsheet, as demanded by the organic certifier, Ecocert. Only marketable produce was weighed in.

At the end of the season crop residues were cut at the base of the soil and left to decompose directly on the beds. Where the ground was bare, a cover crop of either buckwheat or berseem clover was planted, depending on the next years' rotation of crops.

The entire farm operation was managed and worked by two people for the whole season (March 12th–October 21st). That included working in the greenhouse, preparing fields, planting, transplanting, weeding, irrigating, harvesting, marketing and selling, and preparing fields for the winter.

All production was calculated in square feet and then extrapolated into acres (43,560 square feet) and hectares (107,593 square feet) at 2.47 acres per hectare. Pounds are calculated into kilograms at a rate of 2.2.

Crop Comparison Details

The eleven crops chosen were snap beans, dry beans, cabbage, carrots, cucumbers, kale, lettuce, onions, potatoes, summer squash and tomatoes to represent a variety of family groups. They were chosen based on relative importance to La Ferme de l'Aube and United States farmers.

Snap Beans

Snap beans were direct seed planted by hand on May 28th, June 11th and June 25th. Each time a 50-foot bed was planted. There were 5 rows spaced 5 inches apart and seeds planted every 2 inches. The varieties were: Provider and Gold Rush (High Mowing Seeds), and Royal Burgundy (Johnny's selected seeds).

Snap beans were harvested every other day, weighed and recorded.

L'Aube harvested 51.5 kg from 375 sq. ft (137 g/square foot).

This could yield:

5,982.24 kg/acre

14,776.13 kg/hectare

The average yield of snap beans in the United States in 2017 was 8,400 lbs./acre (3,818.18 kg/acre).

From the report titled "USDA data confirm organic yields significantly lower than with conventional farming," snap beans are 21% MORE productive in an organic situation (4,620.00 kg/acre).

Snap Beans	Conventional	Organic	Veganic
Grams/sq. foot	88 g	106 g	**137 g**
Kilograms/acre	3,818.18 kg	4,620.00 kg	**5,982.24 kg**
Kilograms/hectare	9,430.91 kg	11,411.40 kg	**14,776.13 kg**

Vegan-organic farming practices of snap beans from the La Ferme de l'Aube field study were 56% **more** productive than conventional and 29% **more** productive than organic agriculture yields.

Dry Beans

Dry beans were direct seed planted by hand on June 4th. Six 50' rows were planted. There were five rows per bed 5" apart and seeds spaced 2" apart. The varieties planted were Black Turtle, Vermont Cranberry, Cannelini, Quincy Pinto, Moonrise Café, and Jacob's Cattle in equal proportions. All seeds had been saved from the year before by La Ferme de l'Aube.

The dry pods were picked and shucked and the weight of the dry beans weighed in.

L'Aube harvested 17.5 kg from 750 sq. ft (23 g/sq. ft)

This could yield:

1,016.4 kg/acre

2,510.51 kg/hectare

The average yield of dry beans in the United States for 2017 was 1781 lbs./acre (809.55 kg/acre)

From the report titled "USDA data confirm organic yields significantly lower than with conventional farming," it appears that dry beans are 23% LESS productive in an organic situation (623.35 kg/acre).

Dry Beans	Conventional	Organic	Veganic
Grams/sq. foot	19 g	14 g	**23 g**
Kilograms/acre	809.55 kg	623.35 kg	**1,016.4 kg**
Kilograms/hectare	1,999.59 kg	1,539.68 kg	**2,510.51 kg**

Vegan-organic farming practices of dry beans from the La Ferme de l'Aube field study were 21% **more** productive than conventional and 64% **more** productive than organic agriculture yields.

Cabbage

Cabbages were started in 50-cell flats in the greenhouse on April 9th (spring planting) and June 9th (summer planting) Cabbages were transplanted into the fields on May 14th (for early summer). The varieties transplanted in spring were: Caraflex F1, Golden Acre, Red Express and Famosa F1 (High Mowing Organic Seeds). One 50' bed was planted. Two rows were planted 18" apart, with transplants spaced 12" apart. On July 9th (for summer) Copenhagen, Red Express, Caraflex (F1) and Famosa (F1) (High Mowing) were planted. One 40' bed was planted. Two rows were planted 18" apart, with transplants spaced 12" apart.

Cabbages were harvested when ready and were weighed in.

L'Aube harvested 62 kg from 225 sq. ft (276 g/sq. ft).

This could yield:

12,022.56 kg/acre

29,695.72 kg/hectare

The average yield of cabbages in the United States for 2017 was 39,410 lbs./acre (17,913.64 kg/acre)

From the report titled "USDA data confirm organic yields significantly lower than with conventional farming," it appears that cabbages are 38% LESS productive in an organic situation (11,106.46 kg/acre).

Cabbages	Conventional	Organic	Veganic
Grams/sq. foot	**411 g**	255 g	276 g
Kilograms/acre	**17,913.64 kg**	11,106.46 kg	12,022.56 kg
Kilograms/hectare	**44,246.68 kg**	27,432.96 kg	29,695.72 kg

Vegan-organic farming practices of cabbages from the La Ferme de l'Aube field study were 49% **less** productive than conventional and 8% **more** productive than organic agriculture yields.

Carrots

Carrots were direct seed planted using either a hand seed sower or glaser seeder. Three 50' beds were planted. Five rows in each bed 5" apart and seeds sown 1" apart. They were thinned as necessary two times after germination. The varieties planted were: Napoli F1 on May 7th, Scarlet Nantes, Cosmic Purple and Yellowstone on May 14th, Dolciva and Naval F1 on June 4th. Each sowing date a 50' bed was planted. The seeds were all procured from High Mowing Organic Seeds.

The carrots were bunched (10–12/bunch) at harvest, weighed and recorded, deducting the weight of the greens. "Weird" carrots and those that were forked were weighed and recorded and became farmer carrots. Too small or rotten carrots were left in the field and not weighed in.

L'Aube harvested 180.5 kg from 375 sq. ft (481 g/sq. ft).

This could yield:

20,952.36 kg/acre

51,752.33 kg/hectare

The average yield of carrots in the United States for 2017 was 40,750 lbs./acre (18,522.73 kg/acre).

From the report titled "USDA data confirm organic yields significantly lower than with conventional farming," it appears that carrots are 49% LESS productive in an organic situation (9,446.59 kg/acre).

Carrots	Conventional	Organic	Veganic
Grams/sq. foot	425 g	217 g	**481 g**
Kilograms/acre	18,522.73 kg	9,446.59 kg	**20,952.36 kg**
Kilograms/hectare	45,751.14 kg	23,333.08 kg	**51,752.33 kg**

Vegan-organic farming practices of carrots from the La Ferme de l'Aube field study were 13% **more** productive than conventional and 122% **more** productive than organic agriculture yields.

Cucumbers

Cucumbers were started 3 seeds per 3 1/2" pot three weeks before transplanting in the greenhouse. They were transplanted on May 28th at two plants per foot. One 50' row was planted. The seedlings were covered with an insect screen and an agribon-19 floating row cover just until flowers emerged. A second sowing was seeded on June 4th and transplanted on June 25th, covered only with insect screen. 25' were planted. The variety planted was Marketmore 76 (High Mowing).

The cucumbers were harvested daily, weighed and recorded.

L'Aube harvested 76 kg from 187.5 sq. ft (405 g/sq. ft)

This could yield:

17,656.32 kg/acre

43,611.11 kg/hectare

The average yield of cucumbers in the United States for 2017 was 16,120 lbs./acre (7327.27 kg/acre).

Yields from organic production were not found.

Cucumbers	Conventional	Organic	Veganic
Grams/sq. foot	168g	N/a	**405 g**
Kilograms/acre	7,327.27 kg	N/a	**17,656.32 kg**
Kilograms/hectare	18,098.36 kg	N/a	**43,611.11 kg**

Vegan-organic farming practices of cucumbers from the La Ferme de l'Aube field study were 141% **more** productive than conventional agriculture yields.

Kale

Kale was started in 50-cell flats in the greenhouse four weeks before transplanting outside. They were transplanted on May 14th, June 18th and July 23rd in three rows 12" apart. A total of 72 row feet were planted. The seedlings were covered with an insect screen until harvest to discourage cabbage moths. The varieties planted were Darkibor F1 (Johnny's), Weslandse (William Dam), Lacinato (High Mowing) and Siberian (l'Aube). Only Darkibor and Weslandse were sold, the other two varieties were for farmers consumption.

Kale was bunched in the field, weighed and recorded.

L'Aube harvested 205 bunches (40 kg) from 180 sq. ft (222 g/sq. ft).

This could yield:

9,670.32 kg/acre

23,885.69 kg/hectare

The New England vegetable management guide shows that an excellent harvest of kale can produce 18,000 lbs./acre (8,181.82 kg/acre).

Yields from organic production were not found.

Kale	Conventional	Organic	Veganic
Grams/sq. foot	188 g	N/a	**222 g**
Kilograms/acre	8,181.82 kg	N/a	**9,670.32 kg**
Kilograms/hectare	20,209.09 kg	N/a	**23,885.69 kg**

Vegan-organic farming practices of kale from the La Ferme de l'Aube field study were 18% **more** productive than conventional agriculture yields.

Lettuce

Lettuce was started in 50-cell flats in the greenhouse three to four weeks before transplanting. Lettuce was transplanted on May 14th and was transplanted every week until August 20th. Lettuce was transplanted in 3 rows 10" apart and seedlings 10" apart. A total of 180 row feet were planted. The varieties planted were Pirat, Concept, Freckles, Nevada, Red Romaine, Muir, Magenta, and Red Salad Bowl (High Mowing).

Lettuce was harvested in the field, weighed and recorded.

L'Aube harvested 510 heads (76.5 kg) from 450 sq. ft (170 g/sq. ft).

This could yield:

7,405.2 kg/acre

18,290.84 kg/hectare

The average yield of all lettuce (romaine, iceberg and leaf) in the United States for 2017 was 30,585 lbs./acre (13,902.27 kg/acre)

From the certified organic survey from 2016 lettuce yielded 9,640.72 lbs./acre (4,382.15 kg/acre).

Lettuce	Conventional	Organic	Veganic
Grams/sq. foot	**319g**	101 g	170 g
Kilograms/acre	**13,902.27 kg**	4,382.15 kg	7,405.2 kg
Kilograms/hectare	**34,228.61 kg**	10,823.91 kg	18,290.84 kg

Vegan-organic farming practices of lettuce from the La Ferme de l'Aube field study were 88% **less** productive than conventional but 68% **more** productive than organic agriculture yields.

Onions

Onions were started in 1040 flats with approximately 250 seeds per tray on March 19th. They were transplanted in four rows 6" apart and 3" in between onion plants on May 14th. A total of 150 row feet were planted. The varieties planted were: New York Early, Ailsa Craig, Valencia, Gladstone, Dakota Tears and Red Wing F1 (High Mowing Seeds).

Onions were harvested in the field in bunches, weighed and recorded, or allowed to dry in the greenhouse and recorded before storage.

L'Aube harvested 112 kg from 375 sq. ft (299 g/sq. ft).

This could yield:

13,024.44 kg/acre

32,170.37 kg/hectare

The average yield of onions in the United States for 2017 was 53,230 lbs./acre (24,195.46 kg/acre).

From the report titled "USDA data confirm organic yields significantly lower than with conventional farming," it appears that onions are 21% LESS productive in an organic situation (19,114.41 kg/acre).

Onions	Conventional	Organic	Veganic
Grams/sq. foot	**556 g**	439 g	299 g
Kilograms/acre	**24,195.64 kg**	19,114.41 kg	13,024.44 kg
Kilograms/hectare	**59,672.77 kg**	47.212.60 kg	32,170.37 kg

Vegan-organic farming practices of onions from the La Ferme de l'Aube field study were 86% **less** productive than conventional and 47% **less** productive than organic agriculture yields.

Potatoes

Potatoes were planted on May 14th. They were planted 10" apart, one row per bed. A total of 500 row feet were planted. The varieties planted were Altitude, Chieftain and Norland (Pommes des Terres Laurentians); Agria and Desirée (Eagle Creek); Milva, Yukon Gold and Caribe (La Ferme de l'Aube).

Potatoes were harvested in the field, weighed and recorded.

L'Aube harvested 355 kg from 1,250 sq. ft (284 g/sq. ft).

This could yield:

12,371.04 kg/acre

30,556.47 kg/hectare

The average yield of potatoes in the United States for 2017 was 43,100 lbs./acre (19,590.91 kg/acre).

From the report titled "USDA data confirm organic yields significantly lower than with conventional farming," it appears that potatoes are 30% LESS productive in an organic situation (13,713.64 kg/acre).

Potatoes	Conventional	Organic	Veganic
Grams/sq. foot	**450g**	315 g	284 g
Kilograms/acre	**19,590.91 kg**	13,713.64 kg	12,371.04 kg
Kilograms/hectare	**48,389.55 kg**	33,872.68 kg	30,556.47 kg

Vegan-organic farming practices of potatoes from the La Ferme de l'Aube field study were 59% **less** productive than conventional and 11% **less** productive than organic agriculture yields.

Summer Squash/Zucchini

Summer Squash and Zucchini were started in 3 1/2" pots, 3 seeds per pot on May 7th and were transplanted on May 28th. The plants were spaced 18" apart, one row per bed. They were covered with ag-19 row cover to protect from the cold nights and bug pressures until flowering. A second sowing was started on June 4th and transplanted on June 25th, with the same covering methods. A total of 125 row feet were planted. The varieties planted were Dark Green, Cocozelle, Romanesco, Success PM Straightneck and Ronde de Nice (High Mowing) and Genovese (Les Jardins de Ecoumene).

The summer squash was harvested daily, weighed and recorded.

L'Aube harvested 140.5 kg from 312.5 sq. ft (449 g/sq. ft).

This could yield:

19,570.64 kg/acre

48,339.47 kg/hectare

The average yield of squash in the United States for 2017 was 16,910 lbs./acre (7,686.36 kg/acre).

From the report titled "USDA data confirm organic yields significantly lower than with conventional farming," it appears that squash is 10% LESS productive in an organic situation (6917.72 kg/acre).

Summer Squash	Conventional	Organic	Veganic
Grams/sq. foot	177g	159 g	**449 g**
Kilograms/acre	7,686.36 kg	6,917.72 kg	**1,9570.64 kg**
Kilograms/hectare	18,985.32 kg	17,086.78 kg	**48,339.47 kg**

Vegan-organic farming practices of summer squash from the La Ferme de l'Aube field study were 254% **more** productive than conventional and 282% **more** productive than organic agriculture yields.

Tomatoes (Italian type, fresh eating)

Tomatoes were started in 50-cell flats on April 30th in the greenhouse. They were transplanted two weeks later into 3 1/2" pots and transplanted into the field on May 28th. They were planted 18" apart in rows 18" apart. Each was staked with a 4–6' wooden stake depending on characteristics of the plant (determinate or indeterminate). They were planted in an unheated plastic-covered tunnel that was opened during the day and closed during the night (caterpillar tunnel). Irrigation was by on-ground drip irrigation. A total of 50 row feet were planted. Organic oat straw was placed around the base of the plants the first week of July, to discourage weeds and keep moisture. The varieties planted were Amish Paste, Roma (La Ferme de l'Aube), and San Marzano (High Mowing).

Tomatoes were harvested when ready, weighed and recorded.

L'Aube harvested 120 kg from 125 sq. ft (960 g/sq. ft).

This could yield:

41,817.60 kg/acre

103,289.47 kg/hectare

The average yield of tomatoes in the United States for 2017 was 78,870 lbs./acre (35,850 kg/acre).

From the report titled "USDA data confirm organic yields significantly lower than with conventional farming," it appears that tomatoes are 35% LESS productive in an organic situation (23,302.50 kg/acre).

Tomatoes	Conventional	Organic	Veganic
Grams/sq. foot	823 g	535 g	**960 g**
Kilograms/acre	35,850.00 kg	23,302.50 kg	**41,817.60 kg**
Kilograms/hectare	88,549.50 kg	57,557.18 kg	**103,289.47 kg**

Vegan-organic farming practices of tomatoes from the La Ferme de l'Aube field study were 17% **more** productive than conventional and 80% **more** productive than organic agriculture yields.

Productivity yields, waste and greenhouse gas emissions

There are a few different reasons why La Ferme de l'Aube yields were consistently higher than conventional or organic tractor systems.

La Ferme de L'Aube plants rows tighter together than tractor farming allows, thus increasing plants per square foot and increasing yield. The beds at l'Aube are also permanent and raised to allow more cubic feet per plant. When beds are remade by tractors every year, the beds remain flat, but at l'Aube every year the

raised beds get taller, up to 4" in height, so where a 50' x 2.5' tractor-made bed would be 125 sq. ft and also 125 cu.ft, the l'Aube beds would be 156.25 cu.ft. Since most tractor implements are set for 36" beds, more space is also lost due to extra space width.

La Ferme de l'Aube did not spray pesticides whether chemical or biologically prepared.

Because l'Aube does not spray any pesticides, insect pressures are not exasperated. Because frequent sprayings are necessary to control a crop pest and are not 100% effective, the remaining insects become immune and more voracious, potentially causing worse problems.

La Ferme de l'Aube did not use any artificial fertilizers, manures or permanent plastic mulch.

Since L'Aube does not use the above, the plants have time to grow at their own pace. By artificially warming the soil, plants may produce quicker, but also burn out quicker. They may yield a positive first and second yield, but afterwards the soil becomes barren as the nutrients are used up. The l'Aube system of building soil means that plants will continue to grow and produce long after the artificially fertilized fields have stopped.

In the final analysis, averaging all eleven crops (nine for the organic method because data was unavailable for cucumbers and kale) production per square foot, the final totals are as follows:

La Ferme de l'Aube 2018 field study produced on average 336.91g/sq. ft.

The United States conventional 2017 average is 329.45g/sq. ft.

The United States organic 2017 average is 237.89g/sq. ft.

Income

How did La Ferme de L'Aube compare to conventional and organic production in income per kg for each crop?

Crop	Conventional	Organic	Vegan-organic
Snap Beans	$.41/kg	$1.17/kg	**$11.03/kg**
Dry beans	N/a	N/a	N/a
Cabbage	$.44/kg	$1.10/kg	**$2.10/kg**
Carrots	$.50/kg	$.82/kg	**$2.89/kg**
Cucumbers	$.46/kg	N/a	**$1.80/kg**
Kale	N/a	N/a	**$7.05/kg**
Lettuce	$1.05/kg	$1.68/kg	**$7.95/kg**
Onions	$.33/kg	$.72/kg	**$2.23/kg**

Potatoes	$.20/kg	$.71/kg	**$1.56/kg**
Summer Squash	$.68/kg	$.98/kg	**$3.39/kg**
Tomatoes	$.15/kg	$.60/kg	**$0.77/kg**
Totals	$.47/kg	$.97/kg	**$4.08/kg**

La Ferme de l'Aube vegan-organic farm generated **868% more** income than conventional and **421% more** income than organic agriculture practices per kilogram of produce.

Waste

While yield is an accurate measure of the production per acre, and income per kilogram will show the potential for the farmer, waste must also be considered. It has been claimed that up to 1/3rd of all food is wasted. The food supply chain (FSC) has five component parts: agriculture, post-harvest handling, processing, distribution and consumption. To fully understand where food losses are occurring, it is important to break down the categories specific to North America.

*Note that the farmer would normally be responsible for the harvesting and post-harvest handling. Most large operations would then leave the processing and the rest of the FSC to others, while La Ferme de l'Aube was responsible for all areas of the food supply chain except consumer consumption.

For North America (including Oceania):

- Approximately 33% of all cereals are wasted. 12% of the loss is attributed to the farmer.
- Approximately 60% of all roots and tubers are wasted. 47% of the loss is attributed to the farmer.
- Approximately 21% of all oilseeds and pulses are wasted. 57% of the loss is attributed to the farmer.
- Approximately 52% of all fruits and vegetables are wasted. 44% of the loss is attributed to the farmer.

Only in the cereal category is some part of the chain (consumers) more wasteful than at the production level; in every other crop category it is at the agricultural production and post harvest handling where the waste is the largest percentage. (1)

La Ferme de l'Aube's waste for the above crops was:

- Pulses 0%
- Roots and tubers 0% (the unmarketable potatoes and carrots were eaten by the farmers)
- Vegetables: roughly 1% (only about 5 kg of tomatoes were discarded due to being over ripe at the post harvest handling stage)

If waste is to be considered:

- La Ferme de l'Aube 2018 field study produced on average 333.54g/sq. ft. (1% loss).
- The United States conventional 2017 was 249.91g/sq. ft. (24% loss).
- The United States organic 2017 average was 180.30g/sq. ft. (24% loss).

Another difference between large-scale and small-scale farms is the relative importance of the waste. Because small-scale farms have limited space and production in comparison to large-scale farms, every gram of produce is important and post-harvest storing situations need to be precise. Large-scale farms will be rougher with their harvesting, using tractors that cause machine damage and could potentially be more careless in their storage situations based on sheer volume.

Greenhouse Gas Emissions

By eliminating tractors and sprays (whether herbicides, pesticides or fungicides) vegan-organic farming could also be the answer to our greenhouse gas emission problems due to agriculture.

Currently, 8.6% of all United States greenhouse gas emissions are related to agriculture, 556 MMT, CO2 equivalent. (1)

339 MMT CO2 equivalent (61% of total emissions related to agriculture) is specifically attributed to raising livestock animals, including: Enteric Fermentation, Manure Management, N2O emissions from grasslands and urea fertilization.

205.9 MMT CO2 equivalent is related to cropland N2O emissions, specifically synthetic fertilizer, surface leaching and run-off, mismanagement of synthetic fertilizers mineralization (nitrogen not being utilized by the plants) and asymbiotic fixation (supplying fertilizer when ground is too wet), organic amendments (i.e. manure) and residual nitrogen from over-fertilization.

Eliminating animal agriculture will cure many CO2 emission problems. When farmers transition to a plant-based agriculture system, a vegan-organic system could be the answer to feeding us all with the least environmental degradation.

Closing Thoughts

Retooling our United States agriculture food production systems should be considered a high priority. According to this study, while vegan-organic farming may only have produced 2.2% more than conventional farming, it was 41.6% more productive than organic farming. The income generated was 868% and 421% more respectively for the farmers, and waste from La Ferme de l'Aube was less than 1%, while both of the other systems would waste 24%. The 2.2% and 41% production numbers will most likely go up in the future due to fertility building, improved skills in the field and more farmers utilizing vegan-organic practices. Transitioning from conventional and organic farms to vegan-organic farms generates more income per kilogram and per acre of land while increasing the availability of fruits and vegetables to the consumer.

Finally, from the 4th National (U.S.) Climate Assessment:

> Rising temperatures, extreme heat, drought, wildfire on rangelands, and heavy downpours are expected to increasingly disrupt agricultural productivity in the United States. Expected increases in challenges to livestock health, declines in crop yields and quality, and changes in extreme events in the United States and abroad threaten rural livelihoods, sustainable food security, and price stability. (1)

All of our options should be considered moving forward. Small-scale, vegan-organic agriculture should be allowed to join the conversation.

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