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The Coming Grand Solar Minimum

How Will This Event Affect Agriculture?

By Paul W. Syltie, Ph.D.

The world is about to experience an event not seen in about 300 years: a solar minimum that could, according to National Aeronautic and Space Administration (NASA) data, rival that of the Maunder Minimum of about 1600 to 1750 A,D.— a time known as the Little Ice Age—but will in any case likely be equally deep as the Dalton Minimum of 1790 to 1830.[1] We have been experiencing very few sunspots (solar storms) for several months now, and that number continues to drop. February of 2020 revealed no sunspots whatsoever; the last time an entire month produced no sunspots was in August of 2008. So far during 2020 the sun has been blank 73% of the time.[2]

Also during sunspot minima, "coronal holes" on the sun's surface, which are vast regions of the sun's atmosphere that open up into the interior, increase and allow streams of solar particles to escape as a "solar wind."[3] These particles interact with the atmosphere and can interfere with communications systems.

Sunspots normally rise and fall every 11 years, but the coming period is likely to be different. First, let us explore a bit of science.

Snow falling in midsummer is one consequence of a Grand Solar Minimum, as was seen about 200 years ago in the U.S. East and Northeast.

Solar Minimums and Cosmic Rays

Scientists have for some time detected a correlation between historic solar minima with earthquakes, volcanic activity, solar and climate change, correlations that John L Casey and his fellow authors examined in great detail in *Upheaval!: Why Catastrophic Earthquakes Will Soon Strike the United States*.[4] According to Casey, grand minimums are a causal factor in triggering these strong quakes and volcanic activity. During solar minima the magnetic field of the sun decreases, which allows more galactic cosmic rays to penetrate into the Solar System, including the earth. These cosmic rays penetrate deeply into silica-rich volcanoes. Coronal holes, which increase during solar grand minimums, add to the mix. Ben Davidson, an independent climate and space researcher,[5] has done some excellent research on this topic and is now accurately forecasting earthquakes based on this and several other factors.

According to a study by scientists Toshikazu Ebisuzaki and others, it was discovered that the 1991 Mt. Pinatubo eruption may have been triggered by an

See Cosmic Rays Appear, page 2

The Solar Corridor Crop System

Gateway to Higher Corn Yields

By Robert Kremer and C. Leroy Deichman

[Excerpted from *The Solar Corridor Crop System*, Academic Press, London, 2019.]

Since the beginning of civilization, "sowers of the seed" have been dealing with the yield-limiting factors (LF) of crops. For example, irrigation from the Nile River was used to effectively eliminate water as an LF.

Beans planted with corn (maize) produced symbiotic-N while squash aided pest control for Native Americans, and it is reported that some of these early farmers buried fish under the corn hill to mitigate the LF of plant nutrients. Artificial drainage was used to effectively deal with soil oxygen as an LF in what is now some of the most productive farmland in the world.

After all previous LFs are actually removed, the Solar Corridor Crop System (SCCS) is our response to removing the next most LF—incident sunlight—deep, in the corn-field canopy!

Since the development of corn

The Solar Corridor Crop System uses wide row spacing to gain "edge effects," which allows for better use of sunlight and yields as high as for the usual close row spacing.

See Solar Corridors Could Double, page 7

Cosmic Rays Appear to Influence Climate

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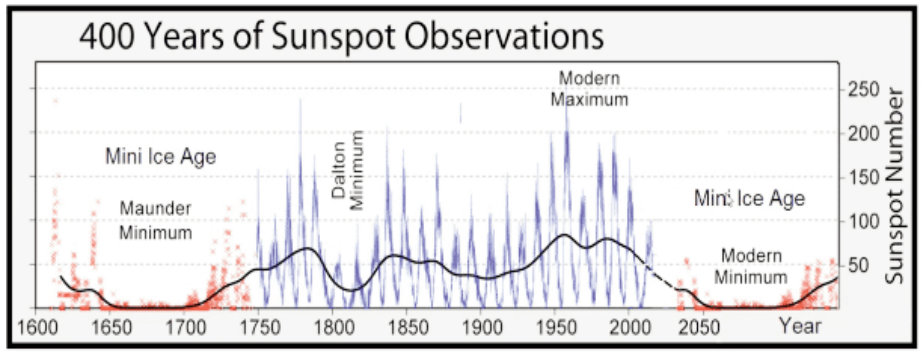
increase in cosmic-rays. Moreover, the timing of 11 eruptive events that produced silica-rich magma from four volcanoes in Japan showed that "Nine of the 11 events occurred during inactive phases of solar magnetic activity (solar minimum). This strong association between eruption timing and the solar minimum is statistically significant to a confidence level of 96.7%."[6]

Research conducted by The Space and Science Research Center in Florida showed a strong correlation between solar activity and the largest earthquakes and volcanic eruptions within the continental U.S. and other regions around the world." The study examined volcanic activity between 1650 and 2009, and earthquake activity between 1700 and 2009, and correlated this with solar activity. "The results of this study showed very strong correlation between solar activity and the largest seismic and volcanic events, within the continental U.S. and globally. The correlation for volcanic activity was greater than 80%, and for the largest earthquakes was 100%...."[7]

Climate Effects

Arthur Viterito, a professor of Geography of the College of Southern Maryland, believes that cosmic impacts such as cosmic rays may also alter our climate.[7] Previously ill-considered cosmic factors beyond our planet are now being taken seriously in the broader scientific community. Among such scientists is Henrik Svensmark, who theorizes cosmic rays impact global cloud cover and thus impact climate to a large degree.[8] An experiment at CERN, Europe's high-energy physics laboratory



near Geneva, Switzerland, confirmed this theory of cloud formation caused by cosmic rays.[9]

The effect of a Grand Solar Minimum on the cosmic ray flux on earth, and thus the frequency of large volcanoes, has been shown in many studies to be a major factor in global temperature. Amongst the several studies that could be cited, one by Liu and others in 2016, who examined the 54 large explosive volcanoes from 501 to 2000 A.D., linked dramatic cooling after the warm Medieval Age to frequent clusters of volcanic eruptions. Contrariwise, the few volcanoes of the 20th century have allowed more solar radiation to heat the oceans and contribute to global warming.[10]

Liu then stated, "There are 54 large explosive volcanoes during 501–2000 A.D. in total, and the strongest one is the Samalas volcano in 1257–1258, which is followed by three smaller eruptions in 1268, 1275 and 1284. These strong volcanoes do not allow the climate to recover, and might have triggered the Little Ice Age."[11]

Thus we see the powerful effect that volcanic debris in the atmosphere has on the amount of radiation that reaches the earth's surface. This may be the major effect that the Grand Solar Minimum has on climate, a blocking of the sun's radiation to the earth's surface ... or a reflection of that radiation to outer space.

What This Means for Agriculture

To understand what this coming Grand Solar Minimum could mean for agriculture in the U.S. and around the world, we need to look back in history to the time of the Dalton Minimum, which was a time of solar minimum from 1790 to 1830, for which we have significant records. A few of these records are recorded in the article that follows below.

Keep in mind that the effects of volcanic eruptions related to the Dalton Minimum may not be repeated during this next 25th Solar Cycle. They could be less harsh, or they could be worse. ❐

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1816: The Year Without a Summer

By Sam Moore

The year was 1816, and was known by such names as "The Year Without a Summer," The "Poverty Year," and "Eighteen Hundred and Froze to Death" or "Starve to Death."

At the time, U.S. agriculture was confined to the original 13 colonies, with most grain grown in New England and eastern New York and Pennsylvania, while the more southern states along the Atlantic seaboard raised mostly cotton and tobacco.

On April 10, 1815, Mount Tambora, a long dormant volcano on an obscure island east of Java, in what is now Indonesia, erupted with explosive force, spewing out vast amounts of molten rock and sending millions of tons of sulphur dioxide and volcanic dust into the air.

The earthquakes and tsunamis resulting from the Mount Tambora eruption killed tens of thousands of people in the islands but wasn't really of much interest to Europe and the U.S., where the news

See The Grain Crop Was a Total, page 3

The Grain Crop Was a Total Failure

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was all about Napoleon's defeat at Waterloo.

Even then no thought was given to the volcano as a cause in the spring of 1816, when the weather across the northern hemisphere began to turn decidedly weird.

The winter itself had been unusually cold, but spring never seemed to come, with hard frosts every month. One Virginia resident recalled, "In June another snowfall came and folks went sleighing. On July 4, water froze in cisterns and snow fell again, with Independence Day celebrants moving inside churches where hearth fires warmed things a mite."

Clothes froze on the line in New England; ice on ponds and lakes was reported in northwestern Pennsylvania in both July and August; and Virginia had frost in August.

The temperature occasionally got into the 90s, but then would drop to nearly freezing in just a few hours.

In upstate New York, crops that had begun to grow were frozen out in early June, replanted, and frozen again in July. Very few crops were harvested and of those that yielded anything were poor.

Food and grain prices went through the roof — in 1815, for example, oats sold for $0.12 a bushel, but by the next year had soared to $0.92 a bushel.

In her book, *Under Old Roof Trees*, published in 1908, Eliza B. Hornby from Warwick, New York, wrote:

"The year 1816 was the coldest ever known in this country. It is remembered as the year without a summer. There were snow and ice every month.

"On June 17th, a terrible snowstorm swept from New England to New York, in which travelers were frozen to death. Farmers worked in overcoats and mittens to but little purpose. Scarcely anything planted grew.

"On our home place were a number of fine fruit trees. The young fruit managed to get a start, when there came a freezing rain. Every cherry, pear, apple, plum and peach was encased in an armor of ice, and was literally shaved from the trees by a fierce, cutting wind.

"On the 4th of July, ice formed an inch thick. There was great scarcity and consequent suffering during the ensuing winter. The grain crop was a total failure."

Much of the rest of the world was affected as well. Excessive rain and cold temperatures prevailed in northern Europe. The potato crop in Ireland rotted in the ground and widespread starvation resulted.

In England, France and Germany wheat crops failed leading to bread shortages and food riots and looting. Northern China was hard hit with thousands of people starving to death. In southern Asia, torrential rains triggered a cholera epidemic that killed many more. ❒

[Adapted from *Farmanddairy.com*.]

On the Lookout for Public Enemy No.1

By the Staff of the Manitoba Cooperator

North Dakota State University is asking farmers to be on the lookout for Palmer amaranth. The No. 1 weed problem in the U.S., hasn't been spotted in North Dakota yet, but it has been identified in neighboring Minnesota and South Dakota as well as in Iowa.

"The plants can grow to be six to eight feet tall, and a single plant can produce up to one million seeds."

In a release, NDSU extension agronomist Tom Peters said Palmer amaranth is a type of pigweed that has devastated crops in the South and Midwest, and has reduced yield up to 91 per cent in corn and 79 per cent in soybeans.

Peters said this aggressive, competitive weed would pose a major threat to North Dakota crops because it can grow two to three inches per day in optimum conditions. The plants can grow to be six to eight feet tall, and a single plant can produce up to one million seeds. Palmer amaranth also is hard to control because it is very prone to being resistant to herbicides.

Dealing With the Problem

The first step in managing Palmer amaranth is to look for it and identify it.

"Scout areas for plants that don't look right," Peters said.

Now is a good time to scout because Palmer amaranth is developing its distinctive long, snaky seed heads, he said. The seed heads can grow up to two feet long.

Identifying Palmer amaranth can be difficult because it resembles redroot pigweed, smooth pigweed and waterhemp.

NDSU has a page to help identify the weed at the NDSU extension website.

The release said Palmer amaranth seeds can spread in a number of ways, including farm equipment, wildlife, wind, and water. Seeds also have been found in native seed mixes used for pollinator or wildlife habitats and in hay. Peters noted that a lot of donated hay came into North Dakota in 2017 because of the severe drought, so producers need to be on the lookout for Palmer amaranth and other weeds. ❒

www.manitobacooperator.ca, August 17, 2018.

15-Minute Soils Course

Lesson 51: Effects of Farming On Soil Organisms

This lesson expands upon Lesson 43 (Summer, 2016), which dealt with the effects of just tillage on soils. Organism activity in the soil has perhaps the most profound influence on long-term overall health and productivity of cropping systems. These organisms, with the average numbers for a European forest soil, include those in the box on the lower left.

A PARTIAL LISTING OF SOIL ORGANISMS (number/meter^3)

Bacteria, of which there are countless species, including...	*10^{14}*
Symbiotic nitrogen fixers	
Nonsymbiotic nitrogen fixers	
Clostridium	
Pseudomonads	
Bacillus thuringiensis	
Actinomycetes	*10^{13}*
Cyanobacteria (blue-green algae)	
Fungi, of which there are countless species, including...	*10^{11}*
Aspergillus	
Penicilium	
Trichoderma	
Mycorrhizae, including ecto- and endo- species	
Algae, including green, brown, and red species	*10^{8}*
Nematodes, of which there are many species	*10^{6}*
Rotifers (ciliated invertebrates)	*10^{4}*
Tardigrades (water bears)	*10^{3}*
Arachnids, including spiders and mites	*50*
Insects, such as beetles and flies, including their larvae	*350*
Centipedes	*30*
Millipedes	*100*
Soil lice	*30*
Earthworms	*100*
Springtails	*10^{5}*

Keep in mind that soil organic matter forms the heart of soil fertility, and soil organism activity is the "heartbeat," as it were, of the organic matter. The organisms do so much to the health of the soil and plants that grow in them by creating a strong soil structure to foster air and water movement, enabling water to infiltrate readily, and by converting essential nutrients to available forms and expediting their uptake by plants. These organisms generate vitamins, growth regulators, phytohormones, antibiotics, phytoalexins, and a host of other beneficial compounds for plant uptake, while the mycorrhizae actually deliver these compounds to the roots for uptake. Earthworms and other macroorganisms feed on decaying plant material and build channels for air and water movement, A healthy soil possesses high populations of diverse species from all floral and faunal groups.

The most common practices of farmers in Western countries are tillage, fertilization, herbicide and pesticide applications, and machinery use, which leads to compaction. All three of these have profound effects on soil organisms, nearly always in a negative direction. Both the kinds and the numbers of organisms are affected. These changes are due in part to a reduction in the amount of plant residues available to feed the organisms, since the species of higher plants grown are very different than the native species.

Other practices that greatly influence the organism populations include...

1. Fertilizer and lime applications. Organisms are especially sensitive to pH, and fertilizer element additions change the soil environment which will favor certain species at the expense of others.

2. Tillage. Moving a tillage shank, a moldboard plow, or a rotary tiller through the soil is

15-Minute Soils Course

like a hurricane that strikes, disrupts, and pulverizes a coastal city...except the city in this case is the mineral, organic, and associated macro- and microorganism population that had previously established an ordered community.

3. Drainage and irrigation. Both of these practices, while tending to normalize moisture conditions that encourage plant growth, will drastically affect soil air and water relations, and affect soil organisms as a result.

4. Herbicides and pesticides. Both of these impact soil organisms directly, and usually in a negative way. For instance, glyphosate—the most widely used herbicide in history—devastates populations of beneficial bacteria like fluorescent Pseudomonas and indole acetic acid-producing bacteria, while encouraging the proliferation of Fusarium bacteria in the roots of corn, soybeans, and other treated crops. The herbicides phorate 1 and menazon kill a large fraction of the soil population before degradation occurs, and insecticides are notorious for killing not only targeted species of insects, but also non-targeted species while damaging soil organisms, often for years after application.

How agricultural practices influence soil biology is summarized as follows. Note that usually the negative effects far overshadow the positive effects, except in drained or irrigated situations.

Positive Effects of Agricultural Practices On Soil Biota

[Drainage, Irrigation, Fertilization, Aeration]

1. New organism species are introduced
2. Larger numbers of the remaining species

Negative Effects of Agricultural Practices On Soil Biota

[Cultivation, Monoculture, Pesticides]

1. Change in the ecological balance
2. Fewer species
3. Larger numbers of some species
4. Some groups are entirely eliminated

Tillage in any form has a harmful effect on the soil biotic community, besides destroying structure and increasing compaction.

To reduce the damage done by modern agricultural practices, farmers have made dramatic shifts towards reduced and zero tillage. These practices greatly enhance soil biotic communities. Moving to organic production further eliminates the use of pesticides and commercial fertilizers, as long as the farmer has the knowledge to manage such an operation. Protecting our precious soil resources is worth every ounce of effort we can afford!

See How Much You Learned

1. One of the most damaging practices affecting soil organisms is tillage. T or F
2. Soil organisms are critical for soil health because they a. create good structure, b. make nutrients available, c. increase compaction, d. improve the infiltration of rainwater.
3. Producing crops using _____methods is a good way to eliminate pesticide use.
4. Among the negative effects of common agricultural practices are a. fewer species, b. larger numbers of some species, c. disrupted ecological balance, d. elimination of species.
5. Drainage of soils can improve soil biota. T or F
6. Name five groups of soil organisms. _____,_____,_____,_____,_____,_____.
7. We should make every possible effort to improve our valuable soil resources. T or F

Answers: 1. T; 2. a, b, d; 3. organic; 4. a, b, c, d; 5. T; 6. look at the table on page 4; 7. T.

Is Vertical Farming in Our Future?

By Sarah Federman and Paul Zankowski

Imagine walking into your local grocery story on a frigid January day to pick up freshly harvested lettuce, fragrant basil, juicy sweet strawberries, and ripe red tomatoes – all of which were harvested at a local farm only hours before you'd arrived. You might be imagining buying that fresh produce from vertical farms where farmers can grow indoors year-round by controlling light, temperature, water, and oftentimes carbon dioxide levels as well. Generally, fresh produce grown in vertical farms travels only a few miles to reach grocery shelves compared to conventional produce, which can travel thousands of miles by truck or plane.

Beyond providing fresh local produce, vertical agriculture could help increase food production and expand agricultural operations as the world's population is projected to exceed 9 billion by 2050. And by that same year, two out of every three people are expected to live in urban areas. Producing fresh greens and vegetables close to these growing urban populations could help meet growing global food demands in an environmentally responsible and sustainable way by reducing distribution chains to offer lower emissions, providing higher-nutrient produce, and drastically reducing water usage and runoff.

The Agricultural Research Service is working on a project to increase U.S. tomato production and quality in greenhouses and other protected environments. We look forward to continuing our partnership with our customers, both internal and external. ❒

https://www.usda.gov/media/blog/2018/08/14/vertical-farming-future, 8/14/2018.

Vertical farming, the stacking of grow boxes and media using artificial light and nutrient solutions, is gaining traction in some areas, and could help feed urban areas.

Organic Can Indeed Feed the World!

By Andre Leu

[This is the final installment of excerpts from *The Myths of Safe Pesticides*, from Chapter 5.]

The greatest of all the myths is that we must be exposed to numerous toxic chemicals; otherwise we will have mass starvation. This myth states that it is impossible to grow enough food without the widespread use of poisons.

The industry, both manufacturers and conventional farming organizations, and regulators consistently argue that not using these pesticides would cause crop failures and dramatic reductions in yields.

The main Australian pesticide regulator, the Australian Pesticides and Veterinary Medicines Authority (APVMA), is a good example of a regulator justifying the use of pesticides: "Pesticides and veterinary medicines are vital to quality food and fiber production. Australia's primary production is worth an estimated $30 billion a year with an export value of over $25 billion. Many primary producers rely on pesticides and veterinary medicines to protect their crops and animals from disease and pests."

When pesticides are being reviewed by regulators for adverse effects to human health and the environment, the industry groups always warn that they have no alternative but to use these toxic chemicals as crop protection tools as the justification for not banning them. In the final outcome, it is usually business as usual, or regulators may decide to modify the way pesticides are used to lessen some negative impacts. Rarely are they withdrawn from use to ensure no adverse impacts on human health and the environment.

Trillions of dollars have been spent on research into conventional agriculture while at the same time in the last hundred years there has been an almost total neglect of research into organic agriculture. A significant proportion of this research funding has been to develop and test the efficacy of synthetic toxic chemicals as pesticides such as herbicides, insecticides, and fungicides.

The main reason for the lower yields in some organic systems has been the fact that research and development into organic systems has been largely ignored. U.S. $52 billion is spent annually on agriculture research worldwide. Less than 0.4 percent (four dollars in every thousand) is spent on solutions specific for organic farming systems.

Yet despite this lack of funding, all the data sets from the global meta comparison studies have examples of organic systems that have the same or higher yields than conventional agriculture. In Iowa trials (the Long Term Agroecological Research (LTAR), a twelve-year collaborative effort between producers and researchers led by Dr. Kathleen Delate of Iowa State University, shows that organic systems can have equal to higher yields than conventional systems.... While the organic systems had lower yields in the beginning, by year four they started to exceed the conventional crops. ❒

"Whenever there are in any country uncultivated lands and unemployed poor, it is clear that the laws of property have been so far extended as to violate natural right. The earth is given as a common stock for man to labor and live on. The small landowners are the most precious part of a state." **Thomas Jefferson**

Solar Corridors Could Double Yields!

Continued from page 1

hybrids and a subsequently robust fertilizer industry, the trend line of average yield increases shows an undeniably enviable performance record. About 42 years later, "the great bulk of maize throughout the US was hybrid," and yet, 111 years later:

1. People are still starving (30 million per year) while the human population continues to increase.
2. People are still addicted to oil
3. Outstanding farmers are still losing their lands.
4. Farmer numbers are still decreasing.
5. Rural communities have declined, even disappeared.
6. Soil is still eroding.
7. Clean water is still being polluted.
8. CO_2 in the air is still increasing.
9. Our most finite agricultural production resource—arable land and its richest topsoil—is still disappearing.

Performance validation data audaciously shows that we can double the corn yield per spatial unit of our most finite crop production resource—arable land! The growing body of evidence further supports the broader hypotheses that the SCCS enhances many soil-health components and subsequent sustainability of not only soil, mankind, and the planet, but the relative viability of the family farm and the integrated rural community. For example, people are starving, vital topsoil is eroding or otherwise disappearing, farm-sourced waters that people drink is being polluted, and the CO_2 concentration of air that people breathe is increasing.

Fewer farms are considered necessary and the subsequent disastrous consequences to rural communities has become an accepted reality.

A practical challenge to the authors is simply to determine the most effective way to describe what the SCCS enables in a short description: "The properly designed, developed, and deployed SCCS enables the production of as much or more corn from half as many rows of corn as is produced from current best management practices (BMP) implemented in state-of-the-art corn production."

"The properly designed, developed, and deployed SCCS enables the production of as much or more corn from half as many rows of corn as is produced from current best management practices (BMP) implemented in state-of-the-art corn production."

The preliminary variety screening study (PST) is the first step of the testing protocol. If we assume an average trend line yield of 176.6 bu from 30,000 plants per acre, the baseline production is a little less than 1/3 lb of #2 corn per plant. This example requires hybrids that produce significantly less than 2/3 pound per plant in the PST to meet our seminal standards for further consideration as an excellent hybrid choice for the solar corridor. With hybrids that meet the above PST for the SCC, an astute farmer, student, or practitioner of corn production can see how corn yield may be effectively doubled. By planting the baseline population with a corn compatible crop on rotational or "floor crop" acres, the SCCS produces both the main crop and the rotational crop in the same field instead of having one crop in one field and the rotational crop in another field (each crop occupies exactly half of the field).

The overall objective of the SCC is to increase sustainable productivity and net operating profits per spatial land unit. The name of the concept comes from the fact that solar radiation in the form of incident sunlight is the basic factor that enables corn producers to increase production. A specific objective of the SCCS is to maximize the effective reception of incident sunlight and its contribution to photosynthetically active radiation (PAR) and radiation use efficiency (RUE).

The premier photochemical energy source and atmospheric CO_2, trapped by the plant, are basic to crop productivity. Remarkable increases in the state of the art, BMP corn production have been largely due to successful manipulation of previously defined LFs using modern management thereby leaving effective access to incident sunlight and CO2—as LFs in modern corn fields. Thus, the SCCS is a means to move beyond the inherent limitations of currently accepted BMPs. ❐

Statement of Purpose

Vital Earth Resources is a for-profit private corporation dedicated to the development, production, and sale of top-quality, ecologically sound horticultural and agricultural products. *The Vital Earth News* is a periodic publication of Vital Earth Resources to inform customers and other interested parties about our products and programs, and to educate our readership on critical issues facing growers today and in the future.

For further information ...

Stay tuned to our website for the next edition of *The Vital Earth News*! You can find current and back issues at *vitalearth.com/vernews,* and keep up to date with the latest information, product news, and announcements at *vitalearth.com/newsandevents*. If you are interested in purchasing our products, or for other correspondence, please email us at *info@vitalearth.com*.

Please include the following in your request:

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Thank you! The Team at Vital Earth Resources, Inc.

Cocoa in Ghana Responds Excellently to Vitazyme

A cocoa trial over two years (2017 to 2019), conducted by the Cocoa Research Institute of Ghana, in four regions and eight locations of Ghana — Ashanti, Brong Ahafo, Eastern, and Western — produced excellent increases in cocoa yields compared to untreated controls.

Experimental design. A 0.8 hectare plot area on each of the eight farms was selected and divided into four equal 0.2 hectare areas, to apply each of the four treatments. The treatments were Vitazyme sprayed at 1 liter/ha in May, June, July, and August, 1.5 liters/ha sprayed at the same times, a foliar fertilizer sprayed at these same times plus in September and October, and no treatment. The experiment was arranged statistically in a randomized complete block design, with the farms representing the replications for each treatment. Fermentable and unusable cocoa pods was tallied at harvest time.

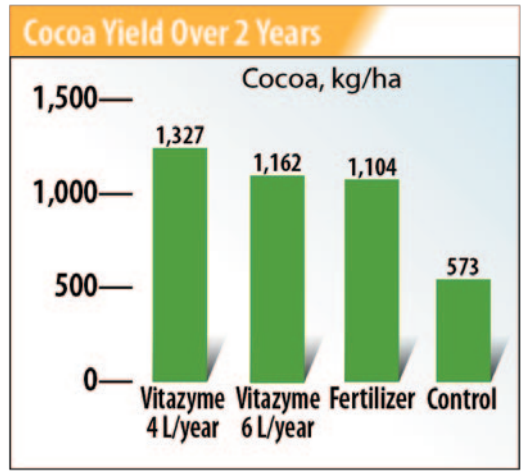
Conclusion. Significantly ($p<0.05$) higher numbers of fermentable pods were obtained from the fertilizer treated plots in the 2017/2018 and 2018/2019 cropping seasons than that of the unfertilized control plots. There was no significant difference ($p>0.05$) between the two rates of Organic Vitazyme foliar fertilizer and the reference fertilizer.

Increased yield above the control
Vitazyme, 4 L/year 132%
Vitazyme, 6 L/year 103%
Fertilizer only 93%

Unusable pods did not differ significantly ($p>0.05$) between the treatments in the 2017/2018 cropping season. Organic Vitazyme applied at 4 liters/ha/year and the reference foliar fertilizer recorded a significantly ($p<0.05$) higher number of unusable pods compared to the unfertilized control treatment in the 2018/2019 season.

The two-year cumulative dry cocoa bean yield was significantly ($p<0.05$) higher in the fertilizer treated plots compared to the unfertilized control. There was no significant difference ($p>0.05$) between the two rates of Organic Vitazyme foliar fertilizer and the reference foliar fertilizer.

Recommendations. The application of Organic Vitazyme foliar fertilizer resulted in higher dry cocoa bean yields compared to the unfertilized control. Organic Vitazyme foliar fertilizer applied at 4 liters/ha/year was comparable with the reference foliar fertilizer in terms of dry cocoa bean yield. The foliar fertilizer had no adverse effect on cocoa trees during the testing period. Based on the comparative performance from the trials, Organic Vitazyme fertilizer is recommended for use on mature cocoa in Ghana.



The application of Organic Vitazyme foliar fertilizer should be done at the field rate of 100 ml in 11 liters of water (1 liter/ha) at monthly intervals from May to August using a motorized spraying machine at restrictor nozzle number 3.

This trial did not evaluate the effect of Vitazyme along with the full or reduced fertilizer rate. It is likely that further yield improvements would have been noted had this combination been used. ❐