THE GERSON INSTITUTE · DEDICATED TO HEALING AND PREVENTING DISEASE

HEALING NEWSLETTER

Vol. 5 No. 2 1989 $3.00

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Healing © 1989
Published by
The Gerson Institute
Gar Hildenbrand, Editor
Membership donation:
$15 / year in U.S.
$20 / year outside U.S.
Gerson Institute
P.O. Box 430
Bonita, CA 92002
(619) 267-1150
Charlotte Gerson, Pres.
Norman Fritz, V.P.

Major portions of *Healing Newsletter* were composed on a *Kaypro 10* computer, donated and maintained by Andrew Kay and Kaypro Computers, Incorporated.

Healing Newsletter is computer typeset by Michael Jablonski, using Xerox Ventura Publisher™

Nutritional superiority of organically grown foods

Experimental evidence for the nutritional superiority of foods grown with organic fertilization

by Gar Hildenbrand

People who grow and eat organic produce like to tell other people that organic fruits and vegetables not only taste better, but that they are "better for you". People who grow and eat commercial produce tend to think that this is a lot of hogwash.

I remember stopping at a nice looking stand in a farmers' market to ask, "Is any of your produce organic?"

The farmer squinted at me, stonefaced, as though I had spoken to him in Swedish. After a short and uncomfortable silence, he answered, "Of course it's organic. If it grows in the ground it's organic."

I asked, "Do you spray it for insects?"

"Of course I do," he answered with a tone of exasperation; "you won't find bugs on any of my stuff."

I was already walking away from his booth as his voice dropped to a disgruntled mutter. I had decided a long time ago that whenever I could avoid pesticide exposure I would. I chose to eat organically grown foods because I reasoned that they were likely to be safer, considering especially the inadequacy of testing in the U.S. and the ineptitude and carelessness of the least competent handlers of these dangerous chemicals.

But, imagine with me for a moment what it might be like if pesticides were no longer a problem. Envision, if you will, a world in which consumer preference has eroded the market for foods grown with toxics. Instead, integrated pest management and biological controls are being used.

In this new scenario, will we really need organically grown foods anymore? Are they so much better than chemically grown foods?

To learn more, we must return to an unsettled argument about the different effects of pure chemical fertilizers versus organic composts.[1-3] This controversy has brewed since the turn of the century.[4-7] Commercial farmers use growth stimulating nitrogen, phosphorus and potassium (NPK) in sometimes very large quantities; organic growers fertilize with only farmyard manure and compost from chemical-free sources.[8]

For many years, the U.S. Department of Agriculture has maintained that there is no discernible difference between conventional and organic produce[9] while organic growers have maintained that theirs is better.[10-12]

Advocates of organic growing methods are united around the idea that organically grown foods are nutritionally superior to chemically grown foods.

Healing has gone to the refereed scientific literature in search of an answer to the question: Has organically grown food ever been scientifically shown to be nutritionally superior to commercially grown food?

Did I hear someone shout "It's already been done! Firman Baer at Rutgers University did a market comparison test in 1984 proving that organics are superior"?

Hold your horses. Gerson Institute Research Associate Christeene Lindsay discovered while conducting our three month literature survey that ALL circulating accounts of "the Firman Baer Report" are bogus. See Lindsay's "...I Saw a Man Who Wasn't There" in this issue of *Healing*.

Some results of our survey

We found that early experiments support the possibility that organic methods can and do produce foods nutritionally superior for some species of animals. But they are not conclusive regarding the human population. Animal feeding experiments conducted in the 1920s by McCarrison[13] and later supported by findings of McSheehy[14] are compelling evidence that there is something fundamentally different and better about plants grown with the benefit of organic composts. In all these experiments, animals fed organically fertilized foods outperformed those fed chemically fertilized foods.

It has been established as scientific fact that plants derive nutrients from the soil.[15-18] In 1929, Rowlands and Wilkinson wrote in the *British Medical Journal* that their findings confirmed those of McCarrison.[20] In their rat study, they compared the healthy growth of rats fed organically fertilized seed with the abnormal growth and disease of rats fed chemically fertilized seed. They used vitamin B replacement to correct the poor health of rats fed "artificial seed", and proposed that such seed may be lacking in vitamin B.

That micronutrients nonessential for plant growth are important in animal and human nutrition is accepted.[21] Whether these micronutrients must be supplied by agricultural products is debated by industry.[22]

Some argue that all necessary nutrients are supplied by conventionally grown foods which are held to be exactly equivalent to organically grown foods in nutritive value.[23-26]

Advocates of organic growing methods are united around the idea that organically grown foods are nutritionally superior to chemically grown foods.[1-7,13,14,20,27-29]

Major differences of opinion stem from the discovery that plants of superior size and appearance can be grown in widely differing soils with the addition of large quantities of growth stimulating nitrogen, phosphorus, and potassium (NPK) fertilizer. USDA hailed NPK as a great advance in farming because its remarkably increased yields promised to feed the world.[30]

In all these experiments, animals fed organically fertilized foods outperformed those fed chemically fertilized foods.

But comparisons of organic and chemically grown foods require much more concrete validation than can be supplied by beliefs, convictions and opinions, no matter how passionate or assertive they may be.

Best experiments

To my knowledge, the only scientific experiments of adequate design and sufficient duration to address questions regarding the composition of organic vs. chemically fertilized foods *in terms of nutrients* are those of Doctor Werner Schuphan, Professor, Lecturer, and for years Director of Germany's Federal Institute for Research of Quality in Plant Production.

In 1974, after thirty-six years of research comparing the soils and plant products of organic compost fertilization with those of chemical fertilizers, Schuphan published findings and conclusions based on a 12-year comprehensive experiment. Conclusions regarding importance of his findings to human nutrition were based on Schuphan's prior labors in human infant feeding experimentation.

Schuphan was definite and emphatic that organically fertilized foods (Stable Manure or Biodynamic Compost) are nutritionally superior to foods grown conventionally with either Nitrogen + Phosphorus + Potassium (NPK) fertilizer, or even NPK-amended barnyard manure fertilization. In *Qual.Plant - Pl.Fds.hum.Nutr.* XXIII,4:333-358, 1974, Schuphan wrote, "*That the consumer would benefit by the higher biological value of products of (fertilization by) Stable Manure and Biodynamic Compost is beyond ques-*

tion, as confirmed by...data based on 12 years' chemical investigations."

It is puzzling to me that excellent writers in the field, like Dietrich Knorr[31] and Katherine Clancy[27] who have both cited Schuphan's 12-year experiment, did not comment on its significance which derives from the strength and chronological length of Schupan's study designs. Perhaps the answer lies in *Qual.Plant's* clubfooted English translation of results of the 12-year study. That translation (in an otherwise generally excellent journal), with its frequently jabberwocky syntax could certainly have proved daunting to even their fine intellects.

I found the going very rough, but after some fretting and frustration over identification of idioms and grammatic intent, meaning surfaced gradually in the murky translation. Schuphan's solid experimental design and intelligent classical methodology revealed themselves in simple clarity.

Strong study designs

Knorr has written intelligently regarding the collective shortcomings of the majority of efforts to compare plant products of different methods and materials of fertilization. He has pointed[31] to three weaknesses common to most studies comparing organic and conventional agricultural systems: 1) the insufficient duration of the studies (most are only one or two years), 2) the choice of pots or plots instead of comparing whole systems (separate farms), and 3) the use of fresh weight (which is quite variable) with emphasis on yield and food quality (organoleptic tests for taste and smell), instead of more accurate dry weights and essential nutrient assays.

While it is true that Schuphan chose to use plots, their great number, the study's long duration, and the use of two different soils minimized the types of bias and error usually found in "flower pot" studies. For example, Schuphan's comparisons of yield for spinach, grown on four different fertilizers over five harvests, incorporated data from *130 separately planted plots*. Measurements of nutrient content for potatoes represent data collected from *104 separately planted plots*. Absolutely none of Schuphan's findings were taken from only one harvest.

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Rather than fresh (wet) weight, Schuphan used dry weight to measure yield, and conducted nutrient assays, soil tests, humus evaluations, and, importantly, toxicology tests.

Allaway called in 1975[32] for strong study designs and replications with emphasis on the inherent deficiencies in some soils. Schuphan has created a study with many replications which utilized both rich soil and nutrient-poor sand.

Through his conscientious efforts to be scientifically thorough, Schupan has far exceeded any measures necessary to comply with guidelines implied by both Knorr and Allaway. I am convinced that Schuphan's design has anticipated any of the usual critical attacks.

Schuphan's Study

To start, 25 concrete framed plots were filled with sand and 25 with fen (lowland rich soil). Each plot had 10 square meters surface (107.64 square feet) and was filled to a depth of .9 meters (2.95 feet). The top layer of the sand plots was mixed with a small amount of fen to improve water holding at the surface.

The plots were designated to receive one of the following types of fertilization: a) NPK, b) Stable Manure, c) Stable Manure + NPK, or d) Biodynamic Compost.

It is important to note the exceptionally large quantity of Biodynamic Compost applied, equivalent to 38.38 tons per acre, in contrast to 13.39 tons of Stable Manure.

Biodynamic Compost and directions for its application were supplied by Dr. Heinze of the Forschungsring für biologisch-dynamische Wirtschaftsweise (Research Circle for Methods of Biodynamic Application) in Darmstadt-Eschollbrücken.

The Stable Manure itself was of "low quality" (low nitrogen) and varied little from year to year. No notes were supplied by Schuphan, regretfully, regarding the nature of the animals nor their feed, e.g.: fresh grasses, grains, silage, hay. In future studies, such information could be valuable in comparisons of various Stable Manuring materials and practices. Likewise not supplied was information regarding the specific genetic strains of seeds.

Statistical significance

To test for conformity of yield, potatoes were planted in eight plots, four sand and four fen, and fertilized with Stable Manure alone. The strong statistical significance of the uniform results in these potatoes can be held as evidence for the reproducibility of the Biodynamic crops which, unlike all the others, were grown in only two plots per harvest (one fen and one sand).

With the exception of the Biodynamic crops, all other fertilizers were tested by planting each crop (eg: potatoes) in four fen plots and four sand plots per fertilizer per harvest, and by growing each crop a number of times over the 12 year period. Eight crops were rotated: spinach, lettuce, savoy (cabbage), potatoes, celeriac (celery root), carrots, fodder beets, and sugar beets. Most rotations were successional, meaning two crops per year in one plot.

Herein lies the strength of Werner Schuphan's studies. He has built an experiment within which is designed a protocol for simultaneous production of multiple replications. Additionally, he has analyzed a representative set of replications for reproducibility and has shown high statistical significance. With the exception of the Biodynamic fertilizer (due perhaps to the sheer weight of fertilizer required), all other experiments have been carried out four times on each of two soils per harvest. In this way, each crop was grown in 26 plots per harvest. That, ladies and gentlemen, is an excellent example of the traditional methods of the Golden Age of German Science.

Where applicable, results were averaged according to four morphological types represented by spinach, savoy, potatoes, and carrots.

Yield

Unfortunately, yield is the contemporary farmer's first concern. We have made it so. If, instead, his first concern were the nutritional value of the produce, his practice would be considerably different. The structure of our economy has not made it desirable or possible for the farmer to put his emphasis on biological value.

Schuphan found that organic fertilization could in no way compete in terms of yields with NPK. He wrote, "These data reflect at the same time the tremendous role of fertilizer practice on yield, and the function of the soil as a significant environmental factor influencing yield."

Dr. Schuphan chose NPK-stimulated crop yields as the representative norm. However, if growers adopt "biological value" as their primary goal, such gigantic chemically pushed yields may become impossible. Never-the-less, using NPK fertilization as the standard (100%) for conventional yield, the bar graph in *figure one* shows that Stable Manure by itself produces only a 54% yield on fen and an even lower 44% yield on sand. By comparison, Biodynamic Composting scored yields of 80% on fen and 72% on sand. The combination of NPK and Stable Manure produced the highest result, 117% yield on fen and 104% on sand.

It is important to note that Schuphan reported that representatives of Biodynamic management plans suggest that yields will be low for five building years.

Different plants

Considerable differences in yield are seen in Schuphan's comparison of spinach (a rosette), savoy (a large terminal bud), potatoes (a stem tubor), and carrots (a storage root). Highest yields in succeeding crops (two crops in one plot in one season) were attained on fen in 1963 by early savoy and carrots, followed by spinach and celeriac in 1969. In single main crops, fodder beets in 1968 led all others.

As expected, in comparisons of four different crops grown by the four methods of fertilization, increased yields of all NPK treated crops are remarkable. In spinach and in savoy, NPK surplus yields ranged up to slightly more than 80% above the competing fertilizers. In carrots, NPK yields were up to 53%

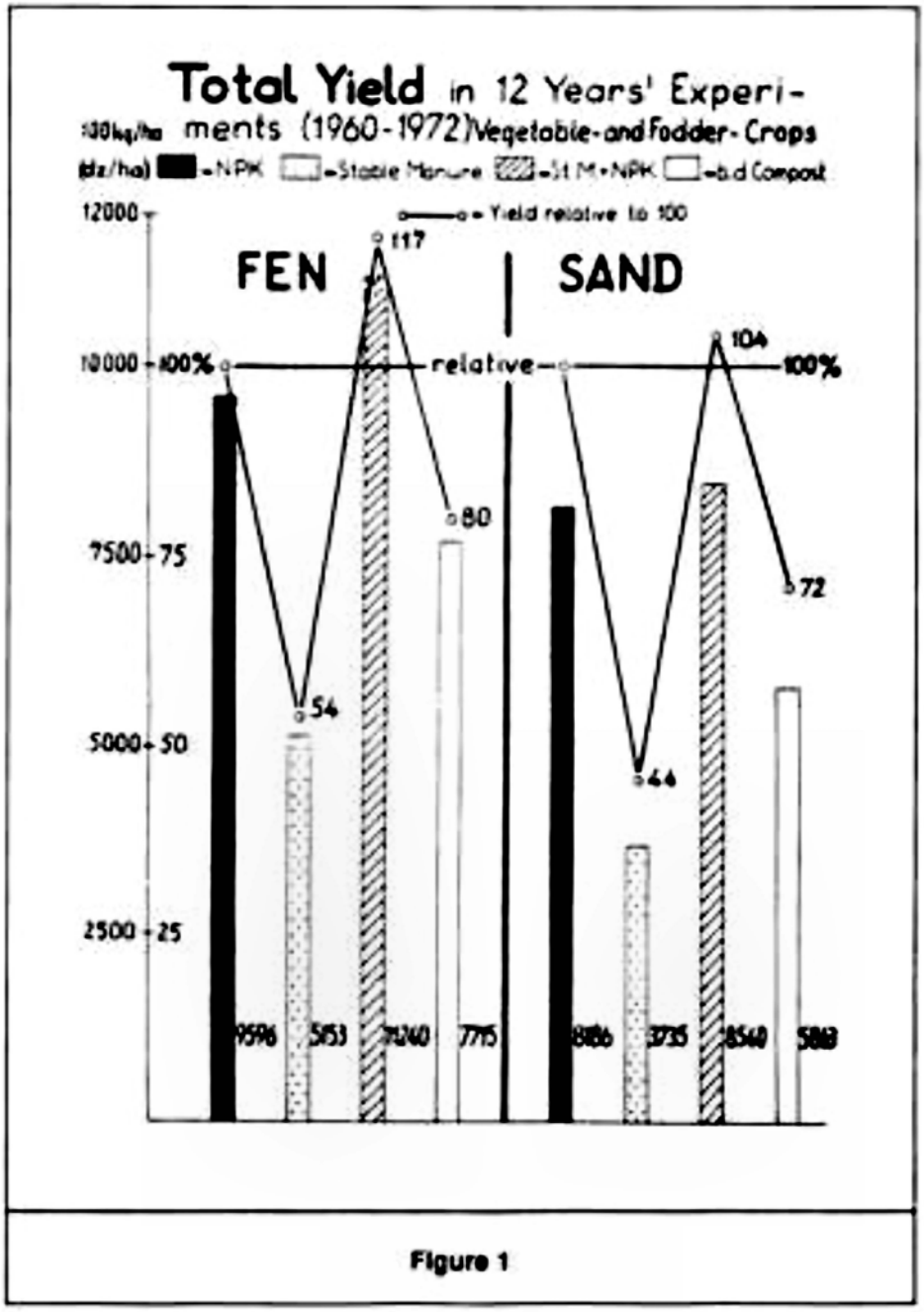

Figure 1

increased, and in potatoes up to 41%. There was one surprising exception to this general rule: potatoes grown on Biodynamically fertilized plots yielded up to 19% above those grown on NPK.

Effect on soil

Soil analyses provided some surprises. Schuphan wrote, "Our expectations after 12 year's experimental work — that humus contents of soil would correspond to humus supply by organic matter — was not realized in fen soil."

Humus is the organic portion of the soil, from decaying plant and animal matter. It is rich with microbes. Theoretically, according to Schuphan, humus is thought to provide abundant plant nutrients which are released by warmth and moisture, the same conditions that stimulate plant growth.

Schuphan observed and reported an apparent paradox: Fen soil in those plots which received the largest yearly quantities of organic inputs (Biodynamic Compost and Stable Manure) tested with the lowest levels of humus at the end of 12 years of consecutive fertilization.

The breakdown was as follows: Fen soil in plots treated with NPK + Stable Manure exhibited the highest humus content on analysis, some 70+ mg/100g soil. In second place for humus content, again surprisingly, was soil from those plots treated with *only NPK*, at 67mg/100g soil. Third place went to plots treated with Stable Manure, at 65mg/100g soil. Biodynamic Compost treated plots were tested at an astonishingly low 55 mg/100g soil, despite the addition of the equivalent of more than 36 tons per acre of Biodynamic Compost yearly for 12 years (compared to 13.39 tons/acre/year of Stable Manure).

Please look at the above paragraph again. Note that fen soil from NPK treated plots, which produced the highest crop yields, and which received absolutely *no organic amendments*, finished 12 years of consecutive, successional cropping with a higher content of humus than either those plots fertilized with Stable Manure or those treated with Biodynamic Compost. Why?

Schuphan did not attempt an answer. It is interesting to note that there was a very small buildup, especially with Biodynamic Compost, of humus in the sand-containing plots which received organic amendments. Again, Schuphan made the observation without discussion. Comparisons of humus and plant nutrients in fen and sand are not without difficulties.[33]

Schuphan conservatively avoided a discussion of mechanisms for the buildup of humus in NPK-treated soil. In addition, he reported extremely high contents of K_2O, Fe, P_2O_5, Ca and Mn in fen soil plots treated for 12 years with Biodynamic Compost. Rationalizing the latter, Schuphan suggested that low yields against high organic inputs might result in such mineral buildups.

"Let us draw the most remarkable results to your attention. The most convincing facts are the much higher contents of minerals — with the exception of sodium — due to organic fertilizing. Potassium and iron show the greatest increases overall. Magnesium and calcium were also remarkably increased in savoy. Contents of sodium, with the exception of potatoes, are markedly decreased."

— Werner Schuphan

More minerals in organics

Regardless of what was happening with the humus, the most important findings resulted from nutrient assays of crops.

I am convinced that Schuphan's design has anticipated any of the usual critical attacks.

In his own words, Schuphan reported: *"Let us draw the most remarkable results to your attention. The most convincing facts are the much higher contents of minerals — with the exception of sodium — due to organic fertilizing. Potassium and iron show the greatest increases overall. Magnesium and calcium were also remarkably increased in savoy. Contents of sodium, with the exception of potatoes, are markedly decreased."*

In 1972[34], Schuphan pointed out that fruits and vegetables have a health-favoring[35] high potassium to low sodium and chloride ratio. This is directly opposed to animal products such as meat, milk, eggs, etc., which do not have a good ratio. Schuphan wrote, *"It must be taken into account that according to our experimental results, attractive cooking methods in which one cooks with plenty of water, throws away the cooking water, and seasons strongly with salt, cause an unfavorable partial displacement of minerals and significant loss of potassium. **This points strongly toward the great value of pressed vegetable and fruit juices for dietetic purposes.**"*

More nutrients in organics

Just a few of the overall findings will suffice to show a trend. Compared with that grown on NPK-fertilized fen, spinach grown on organically fertilized fen soil contained from 64% (Biodynamic Compost) to 78% (Stable Manure) more ascorbic acid (Vitamin C).

In sand, spinach contained 30% (Biodynamic Compost) to 54% (Stable Manure) more ascorbic acid.

Savoy on organically fertilized fen contained 76% (Stable Manure) to 91% (Biodynamic Compost) more ascorbic

acid. Savoy on sand tested at 64% (Biodynamic Compost) to 85% (Stable Manure) more ascorbic acid than that grown on NPK.

On ten soil, both Stable Manure and Biodynamic Compost increased the ascorbic acid content of lettuce by 59%. On sand, the increase was only 6% (Stable Manure) to 9% (Biodynamic Compost).

"This points strongly toward the great value of pressed vegetable and fruit juices for dietetic purposes."

— Werner Schuphan

Against the trend toward higher nutrient contents, carotene-containing crops showed moderate decreases with organic fertilization, as much as almost 20% below the NPK norm. Schuphan noted that carotene is a "surplus product of plant metabolism, its synthesis being promoted by mineral fertilizing and favorable ecological conditions."

The need for more study, both of carotenes in biological (animal) systems, and of their intrinsic nature in plants, is obvious.

Proteins

Relative protein, a concern for those on limited diets, is increased in crops grown on organically fertilized ten soil. The increase in spinach is from 4% (Stable Manure) to 6% (Biodynamic Compost), in savoy from 33% (Stable Manure) to 40% (Biodynamic Compost), in lettuce from 15% (Biodynamic Compost) to 24% (Stable Manure), in celeriac 24% (Biodynamic Compost) to 37% (Stable Manure), and in carrots from 21% (Biodynamic Compost) to 25% (Stable Manure). In potatoes, the increases were only slight, never as much as 10%.

In sand fertilized by organic inputs, the results were similar to the above, with a large difference showing only in carrots which were only barely higher than sand-NPK carrots.

Biological value of protein

The argument of organic vs. chemical fertilization hinges on two opposing issues: 1) maximum yield against 2) biological value.[34] Figuratively, biological value can be thought of as the sum of the actions of all components, both those that exhibit positive action like the vitamins, and those with negative action like the nitrates.[35] Schuphan's findings regarding amino acids and conjugated proteins in the above and the current studies throw much weight to the biological value side of the balance.

Heavy nitrogen fertilization results in a decrease in crops of the sulfur-containing amino acid methionine.[36,37] Methionine is essential in plant metabolism for the transfer of methyl (CH_3) from one compound to another. According to the above and earlier findings of Schuphan, diminished methionine content of crops due to heavy nitrogen fertilization results in decreased biological value of plant proteins.[38]

In the current experiments, both potatoes and spinach grown on organically fertilized ten and sand exhibited increases in methionine (expressed as a % of crude protein) from 11% to 47% above the NPK norms.

Schuphan observed a concurrent slight decrease in both glutamic acid and lysine in organically fertilized plants. In his opinion, enhancement of lysine content of crops, which increases with nitrogen fertilization, is not worth the loss of methionine and overall biological value of conjugated plant proteins. Lysine is touted by some nutritionists as playing a major role in the accelerated growth of young people of the Western World. It is richly supplied by animal foods of which there is plentiful supply. There is no need to devalue plant proteins in search of lysine stores for the public.

Schuphan wrote, *"We may come to the conclusion that organic manuring unequivocally favors sulfur-containing methionine, one of the most important amino acids. Breeders are very keen on genetically improving plant proteins by increasing their methionine contents. We have made it clear, however, that techniques of cultivation — more precisely, techniques of fertilization — may also help in this respect."*

Less water weight in organics

Good looking, giant fruits and vegetables are considered desirable in the food industry. However, the measure of their food value is not their size and harvest weight, but rather their dry weight, which is a measure of their actual contents. Large, beautiful vegetables can be waterlogged and low in nutritional values. As one might suspect from the increased nutrient levels in organically fertilized crops, their dry weight is above that of their chemically fertilized counterparts.

Using chemically fertilized crops as the standard (100%), Schuphan demonstrated increases in dry matter in organically fertilized plants. In some crops treated with Stable Manure the gain in dry weight was as high as 69% above the NPK norm. Some crops treated with Biodynamic Compost ranged up to 96% beyond those fertilized with NPK.

Large, beautiful vegetables can be waterlogged and low in nutritional values.

Lower toxic nitrates

Schuphan earlier published[34] concerns regarding potential health hazards to infants of high Nitrate crops, especially over-fertilized spinach. In this study he wrote, *"The most surprising result is the behaviour of nitrate-N in spinach. Organic manuring both with Stable Manure and Biodynamic Compost results in extremely low contents of nitrate-N. No hazards to health whatsoever could be expected when such a "low-nitrate-spinach" was fed to infants."*

Benefits in pest control

Nitrogen fertilized plants attract aphids more than is normal.[39] Observing that aphids require free amino acids from the stream of the vascular bundles of plants[40,41] Schuphan observed that organically grown plants are less susceptible to aphids for three reasons: 1) they have more collenchymatous thickening and subsequently more strength in cellular walls, 2) they have lower water content, and 3) they have lower contents of free amino acids.

On the whole, Schuphan's results support the argument that organic manuring produces foods which are nutritionally superior to those grown on chemical fertilizer.

Infant feeding studies

In a nine-year set of three separate infant feeding experiments,[42-44] high contents of vitamins and minerals in crops were associated with health benefits to infants, including increases in daily weight gain, carotene in blood, vitamin C in blood, tolerance to teething, serum iron, and an improved red blood picture.

Schuphan points out that the nutritional constituents analyzed in the current studies are the same as those used to determine nutritional value in the infant feeding experiments which ran from 1936-1944. He asserts, "That is the reason why we claim validity for expressing our results in nutritional values."

Bottom line

On the whole, Schuphan's results support the argument that organic manuring produces foods which are nutritionally superior to those grown on chemical fertilizer. Let's look at some averages to help us to understand Schuphan's experimental evidence for the nutritional superiority of crops grown with the aid of either Stable Manure or Biodynamic Compost.

In comparison with NPK-fertilized crops which are assigned the relative norm of 100%, crops grown in both fen and sand with Stable Manure fertilizer or Biodynamic Compost fertilizer averaged higher in positive biological factors and lower in in negative factors (*Figures 2 and 3*).

Schuphan asserts that chemical fertilizers are used solely for a one-sided economic benefit to the food industry through remarkable increases in yield. In my opinion, this does not necessarily translate into gains for the farmer, whose commodities are therefore available often in such surplus that they are grossly devalued in a desperate effort to compete for buyers on the exchanges.[11]

Now that Schuphan has established a factual basis for the nutritional superiority of organically grown foods as they relate to human nutrition, let us look again at the experiments of McCarrison and McSheehy. Findings of this sort in animals, tied now to human nutrition through the labors of Schuphan, suggest the horrible reality that contemporary human nutrition constitutes a long term deficiency feeding experiment.

Findings of this sort in animals, tied now to human nutrition through the labors of Schuphan, suggest the horrible reality that contemporary human nutrition constitutes a long term deficiency feeding experiment.

Standardization of organics industry practices must include generation and collection of the best scientific data regarding nutritional values in order to further the philosophical and practical knowledge and intent which gave birth to the industry. Industry credibility, which is vital, can be enhanced only by careful science.

It is important here to point out that Schuphan's results cannot be said to apply directly to all produce grown by various organic farming methods. It gives us some specific knowledge regarding several specific methods of organic fertilization and crop management. But what we are not told is far greater in scope than what we are told.

Factors having a positive biological influence:

	NPK	Organic
Dry Matter	100%	123%
Relative Protein	100%	118%
Ascorbic Acid	100%	128%
Total Sugars	100%	119%
Methionine	100%	123%
(determined in potatoes and spinach only)		
Potassium	100%	118%
Calcium	100%	110%
Phosphorus	100%	113%
Iron	100%	177%
(determined in spinach only)		

Figure 2

Factors having a negative biological influence:

	NPK	Organic
Nitrates	100%	7%
(determined in spinach only in 1962, 1969, and 1972)		
Free Amino Acids	100%	58%
Sodium	100%	86%

Figure 3

And we must therefore call for wide researches into nutritional qualities of foods grown by different methods of organic fertilization. Schuphan's twelve-year study with its basis in prior infant feeding experimentation should serve as a model for future researches. Other defined methods of organic growing should be put to similar tests.

Industry inertia is massive, and a way of doing business has been entrenched for many years which favors yield and cosmetics instead of biological value.

Industry inertia is massive, and a way of doing business has been entrenched for many years which favors yield and cosmetics instead of biological value. But increasing numbers of consumers are more and more aware, vocal and active, sometimes militantly, against toxics and for nutritionally superior organically grown food.

There is a great, long journey ahead. But tomorrow holds hope if we will only pick up our bags and walk there. ■

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