Impact of Agriculture on Surface and Ground Water: A Comparative Study of Conventional and Organic Farming

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Agriculture has become basic to the development of civilizations ever since man passed beyond the stage of obtaining his food by hunting and gathering. Cultures have risen or fallen with the success or failure of agricultural practices and the capacity of the soil to yield sufficient crops year after year. At the base of agriculture, as well as at the base of social culture itself, is water: an irreplaceable substance for all living organisms. In spite of the fact that this critical role is of common knowledge, we are increasingly threatening the quality and quantity of our water supplies. A major part of the threat to water comes from that activity which is particularly dependent upon it: agriculture. In the United States, agriculture is looked upon as the main cause of water pollution in two-thirds of the river basins. In Europe, agriculturally-caused water pollution is also widespread: in particular the contamination of groundwater with nitrate has become a critical problem.

Because of such environmental impacts, the question of sustainability of the current agricultural system must be raised. Sustainability implies not only continued productivity, but also affordable financial and social costs of the impact on health and environment.

The costs of agricultural emissions are currently covered by taxes, or by the private sector: they are not charged to the emittor, that is to agriculture, as is done - whenever possible - in the case of industrial emissions. The European Organization of Economic Cooperation and Development /OECD/ recently stated that "agriculture is now, to a large extent, in a situation comparable to that of industry twenty years ago. Pollution from modern intensive agricultural methods is constantly increasing, and non-systematic sericus efforts have yet been made to control it. Delaying the adoption of appropriate measures in controlling agricultural pollution is a negative policy for the environment and society /OECD REPORT, 1983/. Even without being held responsible for the financial load it causes, agriculture has begun to feel the pressure of increased costs. This in turn creates pressure to earn more by producing more - generally requiring more chemicals and larger machines, with the result of larger environmental impact. This is an increasing circle of effects, involving more and more parts of the environment, resources and society in general.

In the framework of the subject presented here, the main concern is the effect of the increasing impact of agriculture on water. This work attempts a/ to summarize the current problems, which indicate the severity of the situation, and thus the need for changes, and b/ to examine in what ways the practices of organic farming avoid, or at least reduce these problems. Ideal for this purpose would be data from studies which directly compare the environmental impacts of farms run under conventional and organic guidelines. There is, however, very little information from such studies: most of the comparative work has been aimed at yields, financial aspects, or energy consumption. Up to now, these have been the main points of concern. Only recently have the dimensions of environmental impact, the water impact in particular, become obvious. A number of projects are now being started to assess the environmental impact on a comparative basis. Nonetheless, at present we can create a basis for comparison by examining the available data within the framework of the goals and principles of the two types of agriculture.

Four aspects have been selected for comparison: nitrate, phosphate, water consumption and pesticides.

Groundwater contamination with nitrate

The Water Management Policy Group of the OECD states in a recent report /1983/ on "Diffuse Sources of Water Pollution": "The fact that intensive agriculture is responsible to a great extent for large scale nitrate contamination of aquifers in agricultural basins is now generally recognized." It adds further: "Agricultural production is recognized as very important, but not absolved of its role in the degradation of water resources." This describes the basic, although unnecessary, conflict situation in most industrial countries between a productive agriculture and the attempt to protect the environment and resources.

The nitrate problem has already become critical in many areas, but the worst is yet to come: due to the lag phase between the intensive use of nitrogen fertilizers and their appearance in groundwater, the problem is expected to spread in size, and grow in intensity over the next years. In parts of France for example, the nitrate concentration is increasing at the rate of 2-3 mg/year. An example of such a development is seen in Fig. 1. In Europe, over 500 large drinking water reserves now have a concentration of nitrate high enough to cause concern, many exceeding the 25 mg/l guide level set by the European Economic Community and a number of them are even above the maximum permitted concentration of 50 mg/l /LAHL and ZESCHMAR, 1984/. Adding to the problem is the fact that the slow replenishment of

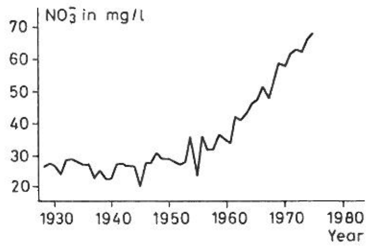

Fig. 1

Increase of nitrate concentration in spring in the Brie region of France between 1930 and 1970 groundwater means a long-lasting contamination, even after the input has been stopped. In those areas where the groundwater - due to its high nitrate concentration - no longer can be used as drinking water various immediate measures have been taken: in some cases it is recommended to buy bottled drinking water especially for infants. In other areas, drinking water is delivered daily by trucks. Longer term measures include the development of methods for the removal of nitrate.

However, whether short or long-term measures, they all increase the price of drinking water - a cost which is borne in some cases by the individual, in others by the government -. But, regardless of who pays for it, it is an added cost of industrialized agriculture. Price, however, is not the only factor of concern. Whether the water treated for the removal of nitrate is of suitable quality for drinking water is another question. For example, water treated by the method of reversed osmosis is not only essentially free of nitrate /over 96% is removed/, but also free of calcium and magnesium /more than 99% of these elements are removed/, two components which are essential to life and required for a good drinking water. Thus additional treatment and more costs are encountered to make the water suitable for drinking.

In spite of the observed increase of nitrate in the groundwater, and the increasing evidence of its risks to health, the use of nitrogen fertilizer continues to increase. Table 1 shows the general trend for a number of countries. Nitrogen use has increased not only in absolute terms but also in relation to the other two main fertilizer components, phosphates and potassium, as seen in Fig. 2. The use of these two other fertilizers has been affected to a large extent by price rises.

The price mechanism is also important in the use of nitrogen: whether or not it is worthwhile for a farmer to increase his use of nitrogen is a

Table 1

The application of nitrogen fertilizer /kg/ha/ in various countries*. 1961/65-1978

/FAO Fertilizer Yearbook, 1979/

Country	1961-65	1966	1968	1971	1973	1976	1978
The Netherlands	125.2	150.0	152.3	175.6	196.1	207.4	215.0
Japan	122.3	142.2	155.8	117.7	145.4	132.9	131.6
Denmark	50.9	71.0	82.2	104.5	122.3	118.8	129.6
Norway	56.4	63.2	69.3	87.5	94.4	106.0	114.1
FRG	53.7	63.3	67.2	83.3	82.0	99.7	102.8
Sweden	32.8	42.8	51.3	62.2	70.9	69.4	68.7
Great Britain	29.5	38.8	44.0	49.4	46.8	59.8	66.5
France	22.3	29.3	37.5	46.7	56.5	56.6	62.1
USA	8.1	11.5	13.1	15.2	17.7	20.7	21.0
Canada	2.1	4.3	3.8	5.3	7.8	9.1	12.3
Australia	0.1	0.2	0.4	0.3	0.4	0.4	0.5

* These figures are averages for all agricultural land including marginal and upland areas not normally fertilized

function of the price of nitrogen and the income of the added yield. The relatively low price of nitrogen fertilizers has added to the economic advantage of using it. The low cost for the farmer is, however, often a hidden cost for the national economy: at present, chemical fertilizers are subsidized in most OECD countries and in some other countries as well. The

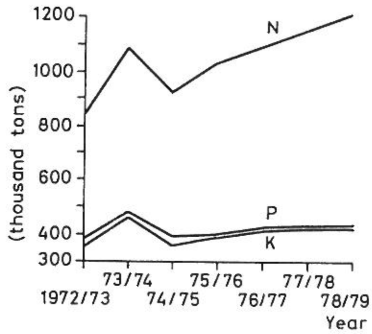

Fig. 2

Use of nitrogen, phosphate and potassium fertilizers in the United Kingdom between 1972/73 and 1978/79

subsidy is either direct or indirect, through total or partial tax reliefs. The OECD reports /1983/ that "... such policies can be viewed as economically inefficient, since their costs for society, at least in OECD countries, now probably far exceeds the limited advantages originally expected." In subsidizing nitrogen fertilizers, the government clearly affects the cost/ /benefit ratio of added nitrogen use, and thus influences fertilizing practices, in turn affecting water pollution and creating further costs for the government.

It is not just the nitrogen fertilizer itself that affects groundwater. Nitrogen has also an effect on soil which increases the problem, as shown in Fig. 3: chemical nitrogen fertilizers inhibit the nitrogen fixing bacteria of the soil, and increase the mineralization of the humus. This in

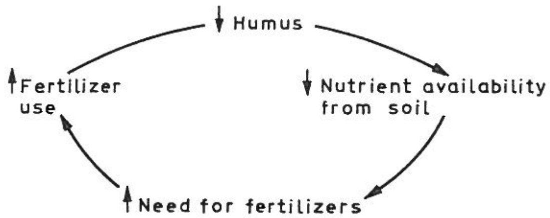

Fig. 3

A "circulus vitiosus" based on the use of chemical fertilizers turn decreases the water retention capacity of the soil, and increases nitrogen leaching, making it unavailable to plants. And this in turn increases the demand for added nitrogen. Such a circulus vitiosus is often seen in today's agriculture.

In general, the nitrate loss to groundwater is a function of the following factors:

- solubility of nitrogen compounds used,
- time of application of fertilizer,
- plant cover /which affects utilization of nitrogen/,
- water retention of soil /function of humus content and plant cover/,
- amount and frequency of rainfall.

With the exception of rainfall, all of these factors can be influenced by the farmer. All of them have been influenced in recent years, but in a direction which has increased nitrate loss:

- nitrogen is used in an inorganic, readily soluble form,
- water retention of soil has been decreased by the loss of humus,
- fertilizer is often applied at a time when the plants cannot utilize it; a part of it is leached out into the groundwater, another part is washed off into surface waters.

The estimates on the percent of leaching vary widely. Calculations based on the amount found in the crop or remaining in the soil, minus that lost to the atmosphere via denitrification indicate that it may be as much as 40-50% which is lost. For fertilized grasslands, which have a constant plant cover, the nitrogen recovery rate is, on the other hand, generally over 80%.

Vertical profiles of nitrate concentrations in pore water below arable and grassland confirm these differences in leaching loss /FOSTER et al., 1982/. The profiles for long-standing arable fields are characterized by a major "nitrate front", which contrasts with the much lower concentrations found beneath fertilized grassland.

As mentioned before, nitrogen application rates are still increasing, and expected to increase further. Since the proportional uptake of nitrogen generally becomes progressively lower with increased application, nitrate leaching can be expected to rise more than directly proportional to use. This effect is furthered by loss of humus.

Nitrogen and organic farming methods - The brief overview above gives an indication of groundwater problems from nitrogen derived from conventional agriculture, as well as the health and economic implications for society as a whole. The next point to consider is in what way, and to what extent organic farming alleviate this problem.

It is perhaps worthwhile to recall to mind some of the basic principles of organic farming which play a role in the avoidance of problems with nitrates /Table 2/.

The difference these factors can make may be seen in a comparison of nitrate loss under field conditions on conventional and organic farms of essentially identical soil and topographical characteristics in Buffalo, Illinois. The two groups of conventional farms showed 47 mg/l and 50 mg/l nitrate in the leach water. The organic farm groups showed 10 mg/l and 8 mg/l /KOEPF, 1980/. This particular study deals only with a comparison of impacts on the environment. It does not give indication of relative yields. Such information we can, however, piece together from other studies. One source of information on organic practices and yields are studies carried out in organic farming research institutes. Some recent work provides data on crop yields and nitrate leaching under the influence of various types of ground covering. In this context it is particularly interesting to look at maize, since this crop is a major factor in the nitrate problem: the long time during which the field lies uncovered contributes to nitrate loss. In the past, indiscriminate attempts to provide soil covering with a cover

Table 2

Some basic principles of organic farming and their effects on soil and nutrients

Action	Effect
Care of soil/humus	- Water retention - Nutrient retention
Use of organic fertilizers	- Slower release of nutrients - Less loss to environment
Maintain plant covering of ground	- Fixing and utilization of nitrogen - Decreased evaporation - Decreased mineralization

crop often led to a decrease in yield, which made farmers reluctant to experiment with this method. Experimental work has shown, however, that the use of an appropriate cover crop /in particular a legume/, planted at a time when it does not lead to crop competition, does not need to lower the yield of the primary crop /Fig. 4/. In addition, the cover crop can be used, depending on needs, as fodder, or left as "green manure" for the field. The data in this figure show the results for the first experimental year. Continuing work on the same fields under the same conditions has shown increases up to 25-30% over the control during the following years. There was a marked decrease in the occurrence of pests as well. This was found to be due to the increased occurrence of favorable insects attracted to the cover crop, as well as an increase in niches for them.

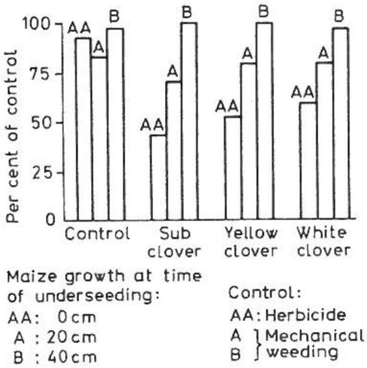

Fig. 4

Effect of clover underseeding on the yield of maize, at different planting times

The lysimeter studies in the same experiment showed a reduction ot nitrate leaching. This can be expected in general from organic farming methods since both the symbiotic N-fixing organisms and organic fertilizers /manure/ provide nitrogen in a form not readily lost to the environment.

The problems of phosphate and soil erosion

A second substance causing problems for water is phosphate. The phosphate problem shares a common factor with the nitrate problem: the use of readily soluble nutrients, as well as the increased mineralization of the soil lead to the leaching of the nutrient. Leached nitrate pollutes mainly the groundwater. Phosphate, on the other hand, tends to be associated with particles, and its movement is thus largely determined by particle transport which implies a horizontal movement associated with erosion. For this reason, phosphate's main impact is on surface waters. Nonetheless, due to excessive fertilizer use, it is being found more and more in groundwater, albeit in concentrations which are only a fraction of those of nitrate. Although phosphate does not present a health problem at these concentrations, it is a further indicator of agriculture's impact on aquifers.

The sources of phosphate pollution are mineral fertilizers, manure, and the erosion of soil containing particle-bound phosphate. Communal sewage systems also contribute phosphate to lakes, but due to the increased phosphate removal via water treatment, this contribution is decreasing. Not only is the percentage contribution from agriculture rising, the absolute amount entering lakes from agriculture is also increasing. In Lake Balaton, approx. 50-70% of the phosphate comes in via run-off, and most of it is from agriculture. In some of the more critically eutrophied lakes in Switzerland, the current load from agriculture is 45-55%. This is expected to rise to 60-75% when the water treatment plants have been equipped with advanced phosphate removal.

The main water problem associated with phosphate is eutrophication. Since phosphate is generally the rate-limiting nutrient in lakes, it is considered as the main factor in the eutrophication process. Thus this problem is closely associated with agricultural activities.

The costs associated with the treatment of eutrophied lakes is another example of externalized costs of the agricultural sector. The methods used to combat eutrophication in "emergency" cases /as is now the situation in several lakes in Switzerland/, such as aeration with oxygen and forced circulation of the water, are in no way inexpensive. By increasing the oxygen content of the lake and thus permitting organism growth and consumption of phosphate, followed by sedimentation, the condition of the lake can be improved. However, even in lakes where the oxygen content appears sufficient, as when aided by aeration, phosphate can still produce problems via excessive algae growth. An example was the death of several hundred thousand of fish in the Sempacher lake in the summer of 1984. The effect of eutrophication goes beyond the internal physical state of the lakes: it also affects their use as recreational centers. This, too, is a side-effect of our agricultural practices.

In addition to the problems occurring directly in the lake, eutrophication causes problems and added costs in the preparation of drinking water. For a number of reasons, it makes its treatment more difficult and costly and tends to impare its final quality. The problems encountered include: rapid clogging of filters by diatoms and other algea; disturbance of flocculation treatment by organic substances; persistent and unpleasant taste and odour; coloration due to manganese, iron or ammonia in abnormal concentrations; the risk of increased bacterial growth in drinking water due to fouling of the distribution networks and to the high nutrient content. In order to counteract a number of these problems, eutrophied water is often highly chlorinated during treatment and distribution /OECD REPORT, 1983/. High levels of both chlorine and organic substances lead to significant concentrations of organochlorinated compounds, which are very undesirable in drinking water /OECD REPORT/.

Part of the phosphate runoff problem lies in the mismanagement of fertilizers: for example, spreading manure on snow-covered ground, which means that a large part of it is carried into the lakes with the first melt. Or using more manure or fertilizer than can be taken up by the plants. /This is often the case for manure, since the farmer is sometimes forced to dispose of it when the storage capacity is full./ Part of the problem is, however, intrinsic to the system of conventional farming: the use of inorganic, easily dissolved phosphates increases the chance for wash-out.

Although farmers increasingly use the services of agricultural stations to measure the phosphate content of soil, in order to better estimate phosphate needs, the result of this test is not always representative of the amount of phosphate actually available: often only dissolved phosphate is measured and not total phosphorus, which can actually become available to the plants. This underestimates utilizable phosphate, and leads to higher recommendations for phosphate than needed.

Another effect of phosphate is the inhibition of phosphatase activity. These enzymes could allow the plant to use organically-bound phosphorous /TREIBER, 1981/. Thus also in the case of phosphate there is a circulus vitiosus: the use of inorganic phosphates creates the need for more phosphate.

The loss of humus and the increase of erosion have also been important in the increased input of phosphates into lakes. Part of this input has been classified as "natural" erosion. However, the fact that this "natural" erosion has increased several fold in the last few decades, would indicate that it is more likely to be of anthropogenic nature. Deep plowing, humus loss and decrease in nutrient retention are associated with this increase in erosion.

Erosion in itself is often a major problem for water. In parts of the world it has taken on critical proportions, threatening future agriculture. The extent of erosion is influenced by soil type, topography, and degree of intensive agriculture, in particular, the use of heavy machinery, mineral fertilizers and uncovered fields. Plant cover is particularly important, since the raindrop is considered the key to the erosion process. A study of the mechanisms of erosion showed that raindrop-induced runoff contained approximately 10 times the sediment concentration of overland-flow-induced runoff /LAKE and MORRISON/. In many parts of the United States, erosion is taking place at a level threatening productivity. Nutrients have to be supplied more and more via fertilizers, which, due to the lack of humus, are readily washed out, causing the water problems mentioned before.

Further, heavy erosion upstream from dams can lead to a more rapid filling up of the dam basin, with a subsequent loss of water storage for irrigation and flood control.

<u>Phosphate and organic farming methods</u> - What can be expected from organic farming with respect to phosphate loss and soil erosion? The same factors that play a role in the decrease of nitrate loss are of significance here: the use of organic forms of fertilizers and proper soil management, which markedly decrease mineralization, erosion and nutrient loss.

For example, a recent case in Germany showed that a maize field planted on a 16-18% slope was losing approximately 200 tons of soil per hectare and year. The use of a cover crop reduced soil loss essentially to zero, without reducing the yield of maize /KLÄY, 1984/.

The way in which manure is treated in organic farming also reduces phosphate loss to the environment: composting the manure means a higher percentage of substances in organically-bound forms, which are slowly released. These various factors together significantly decrease nutrient loss and erosion, thus preventing phosphate loss to the environment.

Water use for agriculture

Water for agricultural purposes, mainly irrigation, now claims approx. 70% of global water consumption. In a number of areas, farming is threatening groundwater supplies to such an extent, that it is endangering sustainability of the social community and itself.

Many factors influence the amount of water needed by agriculture. Among the major ones are: climate, soil type and condition, crop selection and agricultural practices. The destruction of humus and the use of monocultures with herbicides play key rcles in the loss of water. Part of the problem of high water use has derived from forcing agriculture into areas with almost no rainfall and/or with a groundwater supply which is hardly replenished. It is perhaps of interest to note that in many areas the expansion of agricultural lands has been less for food for humans than for animal fodder. In a number of countries, approximately 90% of the grains produced are used for animal fodder. World-wide 2/3 of the grains are used for fodder, thus implying a qualitative and quantitative impact on water resources.

An additional factor increasing water demand has been the development of new grain varieties. These exhibit in general higher demands for fertilizers, irrigation and pesticides, creating problems both of quality and quantity for water.

Organic farming practices and water use - What changes can be expected with organic farming practices with respect to the use of water? There are in fact a number of changes to be observed, the basis of which lies in the different approach to farming and care of the soil.

A look at those factors which affect water loss, and soil loss as well /Table 3/ indicate that the practices of organic farming /see also Table 2/ have a positive influence upon water and soil conservation: all three types of loss - evaporation, runoff and leaching - can be effectively reduced. Further, since these measures help maintain a more consistent moisture content within the root area, the growth and stability of the plants are favored.

Increased stability, particularly in times of dryness, has been observed by many organic farmers. This has also been noted in the large scale experiment with organic farming which is being carried out by the city of Vienna. Via this experiment, Vienna has become the largest organic farmer in Austria, with 139 hectares of organically-run farms. This has been part of a very pragmatic experiment to attempt to save the agricultural area along the Danube from deterioration: until the start of the project in 1976, the entire area was being threatened by the sinking groundwater level and the increasing salt concentration of the soil. Years of intensive agriculture had turned the area into essentially one large hydroculture: the soil itself no longer supplied moisture or nutrients, and thus the

Table 3

Effects of various mechanisms on soil and water loss /LOEHR, 1979/

Mechanism	Effect of water losses	Effect of soil losses
Increase of vegetative cover or surface residue	- Increased soil moisture storage due to increased infiltration and evapotranspiration - Reduced runoff velocity	- Reduced raindrop impact - Reduced rill erosion - Reduced transport capacity
Contour plowing	- Reduced runoff velocity - Increased moisture storage in permeable soils	- Reduced rill and gully erosion - Reduced transport capacity
Reduction of tillage	- Increased soil moisture	- Reduced exposure to raindrop impact - Reduced soil erodability due to improved soil structure
Improvement of soil structure	- Reduced runoff - Increased soil moisture storage due to greater infiltration time	- Reduced rill and gully erosion - Reduced transport capacity

entire area required constant irrigation and continued treatment with fertilizers.

A comparison of the conventional and organic farms in this experiment during years of very different rainfall gives the following picture: the conventional farms, with constant irrigation, have shown a slightly higher production of grains in average years. In the dry summer of 1981, however, the grain yield from the organic farms was twice as high as that of the conventional farms. The stability and reliability of yields are considered major factors in attracting the interest of other farmers to make the conversion to organic farming. The higher market value of the crops and the lower material costs make it also a financial success. These reasons, along with the significantly decreased impact on water, have lead the city to consider not only supporting the conversion of other agricultural areas to organic farming, but even requiring it in the other approx. 1,800 hectares which it owns and leases /PRESSE- UND INFORMATIONSDIENST DER STADT WIEN, 1984/.

Pesticides as a threat to water

The use of pesticides presents problems the full significance of which are only gradually being recognized. Due to their toxicity, their persistence in soil and water, and their accumulation in the food chain, they represent a long-term threat to man and the environment. Although we may have become more aware of the side effects of pesticides since the days of the major DDT problems, the pesticides we currently use still present inherent dangers. Beyond their direct toxicity, their degradation products may also be toxic, and still very little is known about these.

Most pesticides are found associated with soil particles or the plants themselves, but erosion can lead to their transport into surface waters. Their association with soil particles led originally to the opinion that there would be little danger to groundwaters. However, there is a trend to increase the production of non-lypophilic pesticides and to use higher doses, with the inevitable result that pesticides /particularly herbicides/ can be detected in groundwaters with increasing frequency /LAHL and ZESCHMAR, 1984; WEHTJE et al., 1981; JUNK et al., 1976/. Further, they are being found in drinking water. It has been observed that "... current treatment processes are ineffective in removing small amounts of many dissolved organic chemicals. Even charcoal filtration is ineffective after a relatively short time." /JUNK et al., 1976/.

There have been a number of blatant environmental or health problems associated with pesticides. These have often been cases of mismanagement and misuse, particularly in less-developed countries, where information and awareness of the problem may be lacking. These cases of pollution, some causing illnesses and even deaths, belong nonetheless to the general problem of pesticides and agriculture. In the same way, accidents occurring during the manufacture or transport of pesticides /such as the tragedies of Seveso, Italy and Bhopal, India/ represent their harmful impact on man and the environment.

The increasing use and need /which in some cases comes from the use; see below/ of pesticides in agriculture are intertwined with other aspects of conventional farming. Several factors among these are the use of monoculture and the loss of humus decreasing plant resistance and the occurrence of beneficial insects. Further, it has been noted that some pesticides "have been found to alter the physiology of crop plants, making them more susceptible to insect attack." /PIMENTEL et al., 1978/. A similar situation seems to be created by the use of inorganic nitrogen fertilizers. A recent work, entitled "Plants made sick by pesticides - a new basis for the prevention of diseases and pests" /CHABOUSSOU, 1980/ presents observations and data leading to this theory. It has long been known that the use of a soluble nitrogen source can lead to an excess and imbalance of amino acids in plants. This may in part be due to the observed inhibition of proteogenic reactions, thus causing a back-up of certain amino acids. It also changes the dietary value to man. An example is shown in Fig. 5. As the amount of nitrogen fertilizer on potatoes increases, there is a shift in

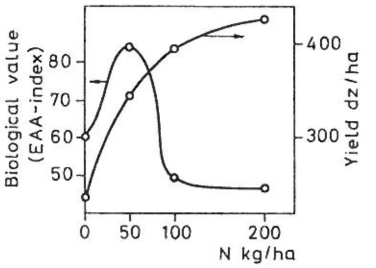

Fig. 5

Effect of nitrogen fertilizer on the biological value /EAA index/ of potatoes /cv. "Bona"/

the occurrence of various amino acids, in this case lowering the value of the potatoes as a protein source. The quantity of the yield, however, continues to increase. Thus, notwithstanding the impairment of quality and the threat to the groundwater, economic reasons persuade the farmer to further increase his use of nitrogen fertilizers.

The increase of free amino acids, which arises from this nitrogen use, apparently serves as a signal for pests to attack the plant. Such amino acids are also found in sickly or dead plants, and these attract insects, which then carry out their role in nature by mineralizing weakened organic material. Apparently nitrogen fertilizers, by rendering plants more susceptible to pests, speed up this process. The farmer's response is to use more pesticides, which increases the impact on water and the threat to man and the environment.

Organic farming and pesticides - Organic farming deals with the problem of pests in a very different way: via healthy soil it raises healthier plants, more resistant to pests. Even in cases where this may not be completely sufficient /for example, unfavorable climatic conditions/, organic farming does not use the chemical pesticides employed in conventional farming. It thus avoids the environmental impact and health problems associated with this source.

Comparative summary of the basic approaches of conventional and organic farming and their environmental loads

The preceding examples can give only a rough comparison of the impact on water via conventional and organic farming. They show, however, that the difference in impact does not arise due to minor differences in practice, but due to major differences in basic goals: conventional farming lays the emphasis upon increases in short-term production, organic farming aims at sustainable productivity.

In meeting the goals of increased production /without taking long-term productivity into consideration/ methods and chemicals are employed which often interfere with the natural reactions and mechanisms of nature /examples: synthetic fertilizers, monocultures/. This often results in decreased ecological stability and in the weakening of plant resistance. The previously mentioned relationship between inorganic nitrogen and pesticides is a good example of how interfering with natural mechanisms can create a problem, which in turn requires further action aggravating the same problem: the oft-encountered circulus vitiosus. A schematic representation of this type of development is shown in Table 4. Its main message is that by working against nature /i.e. interfering with natural processes/, the system is made more unstable. Further, non-natural attempts to correct the situation only aggravate the instability, causing additional undesirable side effects /and associated costs/.

Organic farming, aiming at long-term productivity, concentrates its efforts on supporting natural processes in order to create and maintain the basis for productivity - a healthy soil. By working in the same direction as nature itself, ecological stability is enhanced, negative side effects are avoided, and there is no need for compensating reactions. Table 5 indicates schematically how this positive development can take place: by supporting the forces of nature, much more can be obtained, with far less difficulty and energy.

Table 5

Chain reaction of positive effects in agriculture

GOAL: Sustainable high productivity

Action	Effect
Care of soil → /plant cover, organic fertilizer, etc./	Improved humus
	Decreased loss of water, soil, nutrients
	↓ Increased health of plants and resistance
	↓ Decreased problem of pests
	↓ Increased stability
	↓ Consistent and sustainable production

Much of the progress of conventional agriculture has been based on the use of synthetic aids - fertilizers, pesticides, etc. - requiring little knowledge of the real needs of soils and crops. In contrast, an agriculture which aims at meeting the needs of plants mainly via the soil itself requires knowledge of what soil and plants really need: knowledge of local conditions, of soil type and condition, etc. Much of this information has been neglected and must be revived or reacquired. There is here also a challenge for research: to utilize new methods and scientific knowledge

Table 4

Chain reaction of negative effects in agriculture

GOAL: Yield increase

"Solution"	Effect	Problem
Intensive use of land	Loss of humus	Nutrient /and soil and water/ loss
Use of mineral fertilizers		
Increased use of fertilizers	Increased weight of grain	Stalk too weak for weight; falls over
Hormonal stalk shortener	Shorter stalk, grain grows closer to ground	Increased fungus attack, due to altered microclima and changes in plant metabolism
Fungicide	Reduction of fungus	Fungicide contamination of plant, soil, water
???		

while learning from nature and contributing to the support of natural processes. Much of our past research gives us little help here: it has spent most of its effcrts on looking at the path which has been leading us away from nature and deeper into environmental problems. Studies on the presence and degradability of toxins, maximum acceptable doses, ecotoxicological effects, etc. have consumed time, energy, and money which should now be turned to developing an agriculture compatible with man's health, the environment of the future.

The impact of our current agriculture on the environment and in particular on water is becoming associated with immense indirect costs. There are often additional external costs incurred by the import of fertilizers or chemicals. An economic evaluation including the direct and indirect costs reveals that our agricultural products, which can be bought so cheaply, have become extremely expensive to produce. This consideration is particularly important when agriculture serves not only as the food basis of its own country, but as a main factor in the national economy, via the export of goods: it may be that profits are overestimated by underestimating the total costs involved.

That the environmental/economic aspect has become critical has already gained the attention of the OECD. It's concern is well phrased in its Water Report /1983/: "... in the short-term, the costs of "interfering" with agriculture may be deemed to outweigh costs of action in the water sector. In the long-term, however, the value to future generations of an agricultural system, adapted to environmental considerations, and the legacy of a water resource system not irreversibly contaminated, can be considered far more important."

Conclusion

The current practices of agriculture are endangering future productivity and creating a serious threat to both the qualitative and quantitative aspects of water, Attempts to compensate for this impact, either on the government or private level, are associated with high costs.

A comparison between conventional and organic farming indicates that a major reduction of all types of impact on water is observed with organic farming. This results in a comparable decrease in costs associated with water pollution and with the consequent dangers to health. These environmental and economic issues provide additional pragmatic reasons supporting the adoption of organic farming. Perhaps these points also provide welcome supporting information for those, whose feeling of responsibility toward the environment and toward future generations have long made them realize that major changes in agriculture are critically needed.

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