Why farming with high tech methods should integrate elements of organic agriculture

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Contents

1. Abstract

In the previous article, in a plea for the introduction of transgenic crops in organic and integrated farming, it was announced that the complementary topic, that high tech farmers should integrate elements of organic agriculture will follow up. Some selected arguments for such a view are summarized here. Basically, they comprise a differentiated view on agro-biodiversity outside the production fields, landscape management methods in order to enhance biodiversity levels. Both elements are compatible with basic ideas of organic farming. First, precision farming is given as one example of many ways to support agricultural production with high tech with the aim of reducing energy input, maintain excellent soil conditions and enhancing yield. It is clear from this analysis, that modern agriculture and certain elements of organic – integrated agriculture are compatible. There are sectors of high tech farming such as the introduction of a better recycling scheme and also a better focus on socio-economic aspects, which need to be seriously taken up from organic-integrated farming, a system, which puts a lot of emphasis on those elements and important research data are available. In the final part a new concept of dynamic sustainability is presented.

Keywords: Agriculture, Precision Farming, eco-agriculture, agrobiodiversity, integrated agriculture, organic agriculture, Sustainability, transgenic crops.

2. Introduction

This text is a follow up of the first publication in this journal “Integrated farming: why organic farmers should use transgenic crops (Ammann, 2008b). In this first part the main topics where: (1) The principles of organic farming, (2) In basic processes no difference between natural mutation and genetic engineering (3) conventional crops have more transcriptomic disturbances than transgenic crops and (4) therefore there is no basic reason for organic farmers not to use selected GM crops, as long as they fit into organic farming systems – they can help to control pests and weeds in an ecological way and at the same time they secure better yield and higher agricultural production. In a short outlook it was also mentioned, that agricultural biodiversity needs a subtle and balanced view and conventional agriculture should take up more ecological thoughts and strategies. Clearly, traditional knowledge is still an unknown reservoir of ecological wisdom and also social networking structures are in many cases of modern agriculture a desideratum for many reasons.

The complementary text here was announced in the conclusions: This time, we ask the question, whether farming with transgenic crops should adopt some of the organic/ecological production strategies. The answer will be similarly differentiated as in the previous piece.

There are hundreds of ways to practice farming with high tech methods, just as well as there are innumerable ways of practicing ecological and organic farming. It is not the aim of this second article to give a complete overview of modern farming methods, we concentrate here again on giving a comparison in contrast of farming with organic/ecological methods versus farming with the use of high tech applications including transgenic crops. Again the aim will be to reduce the contrasts, often exaggerated, driven by ideology on both sides. In the first part the concept of organic farming was described with the recently published principles of IFOAM (International Federation of Organic Agriculture Movements). In the case of the mainstream agriculture this is not so easy, since literally hundreds of organizations have their guidelines and constitutions. There is an extremely broad palette of opinions and views manifested in hundreds of papers. Therefore again we resort to an aspect of modern agriculture which is still in starch contrast to organic farming – and again, the strict boundary in-between is to be questioned.

3. Concepts of farming with high tech methods, the example of precision farming

Usually, farming with high tech methods is understood as *Precision Farming (PF)*. As all such expressions, they are a label for a strategy, here with the means of satellite steered farming with geographical information systems or other (remote) sensing methods, combined with high tech sowing and harvesting machines. PF is not a single technology, but rather a suite of technologies that can be assembled into a system (Batte & Arnholt, 2003). Farmers are expected to adopt various component technologies, depending on their needs and other site-specific characteristics of the business.

It is a set of farming methods , which has been introduced primarily in the North American naturally treeless regions (previously covered by prairie vegetation) and rich soils, ideal for industrial farming with heavy machines and high production levels, but nowadays it is rapidly spreading all over the world in countries with good infrastructure resources in agriculture.

PF can be used for remote control also in relatively small structured agriculture, for instance for improved crop discrimination, (Sai & Rao, 2008) were able in India (Hyderabad) to distinguish by satellite remote sensing (Resourcesat-1) between ca. a dozen of crops/cultivation types. A lot of research papers demonstrate nicely in colorful illustrations, that satellite mapping is en vogue and will deliver ultra-exact imaging in the future. However, the activity still concentrates in research, but the applications do not yet reach a broad range as GM crops per se do (James, 2009).

PF has also been evaluated to assess important soil parameters like organic matter (OM) in real time mode (Christy, 2008), below the figure about the calibration, it shows a comparison of two predictions of OM for field 3, one using a whole-set calibration and the second using a field-3-out calibration. The field-3-out prediction, whose accuracy is estimated by one-field-out validation, is plotted against whole-set prediction, whose accuracy is estimated by one-(sample)-out validation. As shown on the plot, the two are highly correlated (R2 = 0.95) and the primary difference between the two can be characterized by a linear equation. Such high R2 figures are not unusual in multivariate calibration, as has been shown for instance in the calibration of biomonitoring air pollution with a set of 40 species of epiphytic lichens (Ammann et al., 1987; Herzig et al., 1989; Liebendorfer et al., 1988).

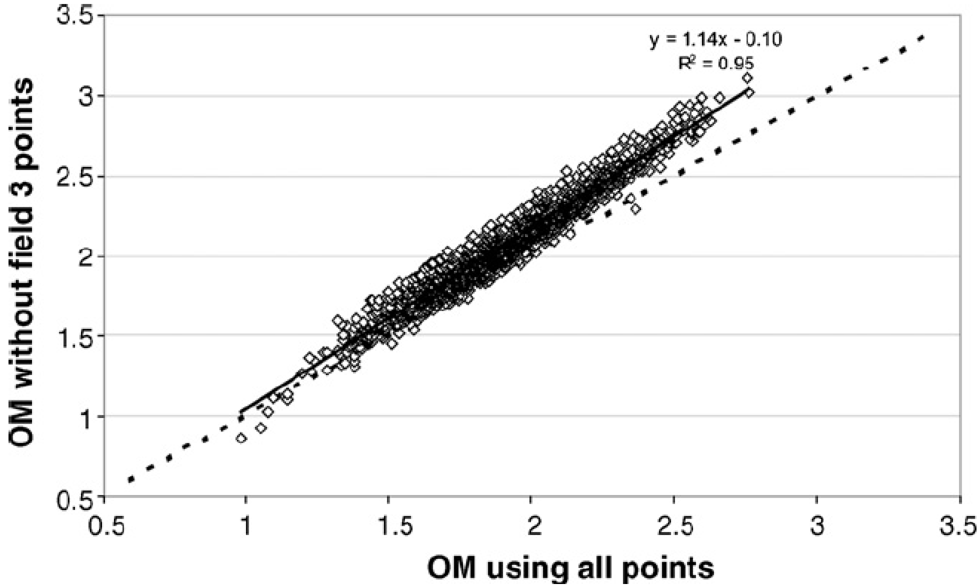

Figure 1 Comparison of Organic Matter (OM) for field 3 made with and without calibration data from field 3. Fig 6 from (Christy, 2008)

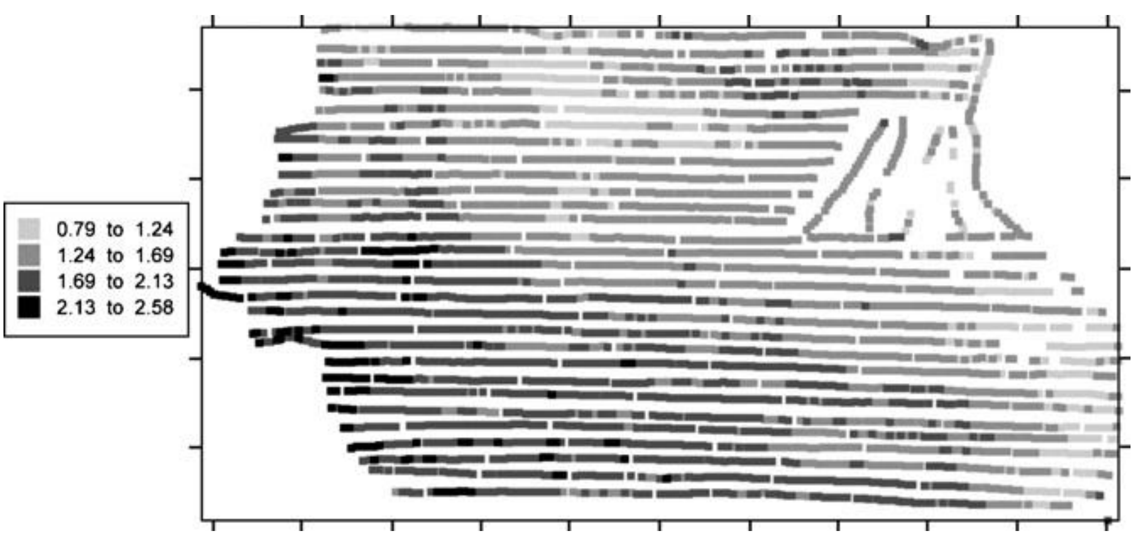

Figure 2 Map of predicted Organic Matter (OM) for field 6. Fig 7 from (Christy, 2008)

The above image could be quite useful for the selection of sample locations or the comparison of locations within a field.

In a recent review, (Kitchen, 2008) come to conclusions with an integrative spirit, that the use of computers and sensors for real-time decisions is growing rapidly, but the real value of the technology can only be translated to optimal agricultural management, if those data are integrated with agronomic knowledge and experience.

(Lamb et al., 2008) give the same cautious picture, calling for an more distanced view in innovation, since very few technologies associated with PB have reached the end of the hype cycle, which the author takes as a normal phenomenon in innovative agricultural development, it holds true for PF, but also for other technologies like genetic engineering (or gene splicing), for which we are undoubtedly in the slope of enlightment (typically enough opposed by conservative people who question even historic enlightment today), and in a few cases of major GM crops in the plateau of successful productivity (James, 2009).

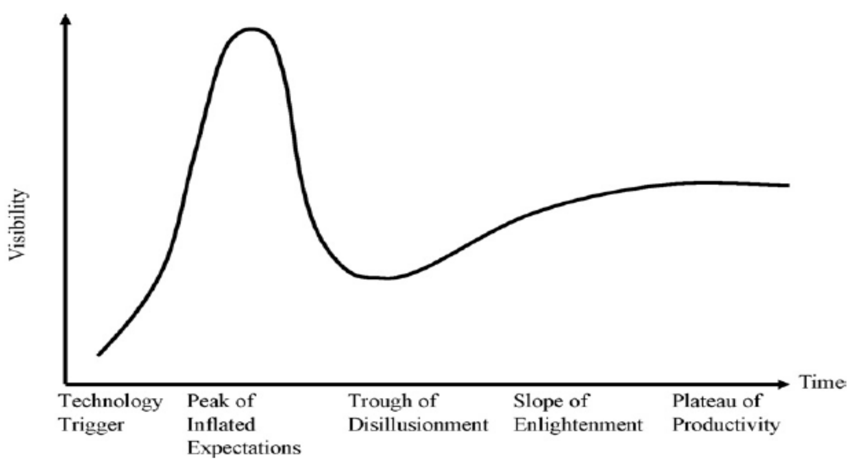

Figure 3 The five key stages of the Gartner Hype Cycle from (Lamb et al., 2008) (adapted from (Gartner, 2008).

PF is of growing importance in automatic weed recognition, a number of papers have been published over the years, some remarkably early, thus documenting some of the five key stages of fig.3 properly, (Franz et al., 1991; Guyer et al., 1993; Guyer et al., 1986; Samdur et al., 2003; Sogaard, 2005; Woebbecke et al., 1995), the most recent review demonstrates progress in science *and* practice: (Ishak et al., 2009).

There are cases of automatic weed control combined with robot weeding reviewed and promoted by (Slaughter et al., 2008). There are several prerequisites necessary for a functioning robotic weed control system: (1) machine vision-based automatic row guidance in real time (accuracy a few centimeters!), also able to work in sown (not planted) field rows, with a capacity of weeding also densities up to 200 weeds/m^2. Ability to work with missing plants in the row (in organic fields where emergence is about 70%, conventional fields usually with an emergence of 90%). The vision system must be adaptable to local and regional conditions in soil and climate. (2) Essential is also the ability of the vision system to recognize plant species on the basis of biological morphology.

But PF is not always done with remote sensing methods: Recently (Sudduth et al., 2008) worked out a comparison with two prototype soil strength profile sensors with promising results.

And also when it comes to map more precisely yield, remote sensing methods are well established: (Drummond et al., 1999; Ehlert, 2002; Pelletier & Upadhyaya, 1999; Reyniers et al., 2002; Whitney et al., 1999).

There is also a new trend in ecological and organic agriculture for precision farming, although often with a less technological touch, with strong emphasis on local knowledge built on social networks and integrated decision making systems. Electronics play still a minor role and remote sensing via satellite imaging is – to the knowledge of the author – still absent the peer reviewed literature – although (Taylor, J. A. et al., 2007) is considering such tools. This paper still remains a rare example of precision agriculture, proposing "down to earth" electronic sensors that respond strongly to clay content and soil moisture in non-saline soils in order to determine important parameters for the management system. Coupling the information from ECa sensors with other crop sensors, such s yield monitors and crop imagery, has promoted according to Taylor the concept of management classes among Australian grain producers. Another rare internet finding is a conference paper of Koopmanns and Zanen (Koopmans & Zanen, 2007) outlining the future use of remote sensing and precision farming methods in organic farming. The aim of this study was to assess the effects of a GPS-controlled precision tillage system using permanent tracks on soil structure, nutrient use efficiency and spinach yield. The study was carried out at an organically-managed arable farm in the Netherlands. See also (Delgado & Bausch, 2005; Delgado et al., 2001)

4. Elements of organic/ecological farming which could be adopted by farmers using modern agricultural technology

As was elaborated in the first part of this article and its preceding text in the Handbook of IP methods (Ammann, 2007b, 2008b) there are controversial views existing about biodiversity in general and in agriculture. This topic has also been covered more broadly in (Ammann, 2008a, 2009b), here we concentrate on the case of agro-biodiversity: Biodiversity within the field cannot be the solution, although the results of the British Farm Scale Experiments suggest that this is basically a good thing: But there are two reasons of doubt: Some weeds provide to the harvest toxic substances, an old problem in agriculture. It cannot therefore be the goal of such experiments to enhance biodiversity within production fields. For an extensive critical comment about the British experiments see (Ammann, 2005).

Around the same time, and independently a book on the same topic, the marriage of organic farming, genetics and the future of food was published, offering a broader view including food on the subject, but centered on the Californian situation (Ronald & Adamchak, 2008), provoking the reviewer to coin the term *orgenics*, which is unfortunately already taken for other purposes. (Gressel, Jonathan, 2009).

5. The case of agro-biodiversity

Species and genetic diversity within any agricultural field will inevitably be more limited than in a natural or semi-natural ecosystem. Many of the crops growing in farming systems all over the world have surprisingly enough ancestral parent traits which lived in originally in natural monocultures (Wood & Lenne, 2001). This is after all most probably the reason why our ancestral farmers have chosen those major crops. There are many examples of natural monocultures, such as the classic stands of Kelp, *Macrocystis pyrifera*, already analysed by (Darwin, 1845), and more relevant to agriculture: It has now been recognized by ecologists that simple, monodominant vegetation exists throughout nature in a wide variety of circumstances. Indeed, (Fedoroff, N. V. & Cohen, 1999) reporting (Janzen, 1998, 1999) use the term 'natural monocultures' in analogy with crops. Monodominant stands may be extensive. As one example of many, Harlan recorded that for the blue grama grass (*Bouteloua gracilis*): 'stands are often continuous and cover many thousands of square kilometers' of the high plains of central USA. It is of the utmost importance for the sustainability of agriculture to determine how these extensive, monodominant and natural grassland communities persist when we might expect their collapse. More examples are given in (Wood & Lenne, 1999a), here only a few more cases: Wild species: *Picea abies*, *Spartina townsendii*, various species of Bamboos, *Arundinaria ssp, (Gagnon & Platt, 2008), Sorghum verticilliflorum*, *Phragmites communis*, and *Pteridium aquilinum*. Ancestral cultivars are cited extensively by (Wood & Lenne, 2001): Wild rice: *Oryza coarctata*, reported in Bengal as simple, oligodiverse pioneer stands of temporarily flooded riverbanks (Prain, 1903), Harlan described *Oryza* (Harlan, J. R., 1989) and illustrated harvests from dense stands of wild rice in Africa (*Oryza barthii*, the progenitor of the African cultivated rice, *Oryza glaberrima*). *Oryza barthii* was harvested wild on a massive scale and was a local staple across Africa from the southern Sudan to the Atlantic. (Evans, 1998) reported that the grain yields of wild rice stands in Africa and Asia could exceed 0.6 tonnes per hectare — an indication of the stand density of wild rice.

Botanists and plant collectors have according to (Wood & Lenne, 2001) repeatedly and emphatically noted the existence of dense stands of wild relatives of wheat. For example, in the Near East, (Harlan, J. R., 1992) and (Hillman et al., 2001) noted that 'massive stands of wild wheats cover many square kilometers. (Wollstonecroft et al., 2008) reported that wild einkorn (Triticum monococcum subsp. boeoticum) in particular tends to form dense stands, and when harvested its yields per square meter often match those of cultivated wheats under traditional management. (Harlan, J. & Zohary, 1966) noted that wild Einkorn 'occurs in massive stands as high as 2000 meters [altitude] in south-eastern Turkey and Iran'. Wild emmer (Triticum turgidum subsp. dicoccoides) 'grows in massive stands in the northeast' of Israel, as an annual component of the steppe-like herbaceous vegetation and in the deciduous oak park forest belt of the Near East (Nevo, 1986). According to (Wood & Lenne, 2001) they are the strongest examples embracing wild progenitors of wheat: (Anderson, 1998) recorded wild wheat growing in Turkey and Syria in natural, rather pure stands with a density of 300/ m².

Nevertheless, agricultural ecosystems can be dynamic in terms of species diversity over time due to management practices. This is often not understood by ecologists who involve themselves in biosafety issues related to transgenics. They still think in ecosystems close (or seemingly close) to nature.

Biodiversity in agricultural settings can be considered to be important at country level in areas where the proportion of land allocated to agriculture is high: Ammann in (Ammann K. in: et al., 2004). This is the case in continental Europe for example, where forty five percent of the land is dedicated to arable and permanent crops or permanent pasture. In the UK, this figure is even higher, at seventy percent. Consequently, biodiversity has been heavily influenced by humans for centuries, and changes in agrobiological management will influence biodiversity in such countries overall. Innovative thinking about how to enhance biodiversity in general coupled with bold action is critical in dealing with the loss of biodiversity. High potential to enhance biodiversity considerably can be seen on the level of regional landscapes, as is proposed by (Dollaker, 2006; Dollaker & Rhodes, 2007), and with the help of remote sensing methods it should be possible to plan for a much better biodiversity management in agriculture (Mucher et al., 2000). This is also a good point for organic farming in marginal regions like the Norwegian Sognefjord. An analysis has shown the positive influence of small scale organic farming in this region (Clemetsen, Morten & Jim van Laar, 2000). Some of the more important papers demonstrate the intensive research activities: (Belfrage et al., 2005; Boutin et al., 2008; Clemetsen, M. & J. van Laar, 2000; Filser et al., 2002; Hadjigeorgiou et al., 2005; Hendriks et al., 2000; Jan Stobbelaar & van Mansvelt, 2000; Kuiper, 2000; MacNaeidhe & Culleton, 2000; Norton et al., 2009; Rossi & Nota, 2000; Schellhorn et al., 2008; Stobbelaar et al., 2000). A bibliography, containing a total of over 300 papers dealing with the impact of ecological agriculture on landscapes and vice versa: (Ammann, 2009a).

Centres of biodiversity are a controversial matter, and even the definition of centres of crop biodiversity is still debated. Harlan (Harlan, J. R., 1971) proposed a theory that agriculture originated independently in three different areas and that, in each case, there was a system composed of a center of origin and a noncenter, in which activities of domestication were dispersed over a span of five to ten-thousand kilometers. One system was in the Near East (the Fertile Crescent) with a noncenter in Africa; another center includes a north Chinese center and a noncenter in Southeast Asia and the south Pacific, with the third system including a Central American center and a South American noncenter. He suggests that the centers and the noncenters interacted with each other.

There is a widespread view that centers of crop origin should not be touched by modern breeding because these biodiversity treasures are so fragile that these centers should stay free of modern breeding. This is an erroneous opinion, based on the fact that regions of high biodiversity are particularly susceptible to invasive processes, which is wrong. On the contrary, there are studies showing that a high biodiversity means more stability against invasive species, as well as against genetic introgression (Morris et al., 1994; Tilman et al., 2005; Whitham et al., 1999). The introduction of new predators and pathogens has caused well-documented extinctions of long-term resident species, particularly in spatially restricted environments such as islands and lakes. One of the (in)famous cases of an extinction of an endemic rare moth is documented from Hawaii, it has been caused by a failed attempt of biological control (Henneman & Memmott, 2001). However, there are surprisingly few instances of extinctions of resident species that can be attributed to competition from new species. This suggests either that competition-driven extinctions take longer to occur than those caused by predation or that biological invasions are much more likely to threaten species through inter-trophic than through intra-trophic interactions (Davis, 2003; Howarth, 1991). This also fits well with agricultural experience, which builds on much faster ecological processes.

Now that many of the biodiversity myths related to agriculture are clarified, it is becoming obvious, that the best thing we can do for biodiversity in agriculture, is taking better care of the landscape structure, this is where high tech agriculture can learn from organic and integrated farming.

But also on a micro scale of the seed production biodiversity could play a new role. Precision Biotechnology could also mean a combination of resistance genes, this can be done through gene stacking (Al-Ahmad & Gressel, 2006; Lozovaya et al., 2007; Taverniers et al., 2008) or taking up the idea of artificial gene clusters (Thomson et al., 2002). This is the normal strategy up to now.

But this goal could be achieved in a much simpler way: Other than complex gene stacking it would be easier to create a seed mix where each seed contains one a single resistance, the appropriate mixture could be adapted to the local pest situation. This would considerably lower selection pressure (Ammann, 1999). This would create a situation, which comes closer to nature, where we encounter many genomes within a square mile and dozens of different resistance genes. If we refrain from heavy pesticide use, beneficial insects will come back – as they do in Bt maize fields, (Candolfi et al., 2004; Marvier et al., 2007; Wolfenbarger et al., 2008) adapt to GMO's.

Much has been written on agricultural biodiversity, foremost the book of Wood and Lenné (Wood & Lenne, 1999b) should be mentioned here, since it is a refreshing mix of modern agriculture and independent views on biodiversity. Each chapter, written by some of the best experts in the field, deserve to be taken up in the future debate on agriculture and biodiversity. The chapter 9 on traditional management written by (Thurston H.D. et al., 1999) . A very enlightening table is given here, it sums up a lot of literature and demonstrates very well the numerous possibilities, in which way biodiversity in the context of agriculture can be influenced:

Table 9.1. Effects of selected traditional agricultural practices on agrobiodiversity. Main source: Thurston (1992).

Traditional practice	Benefits for agrobiodiversity	References
Multiple cropping (intercropping; polycropping; home gardens)	Maintains biodiversity as interdependent crop variability Often reduces damage from pests and diseases favouring maintenance of agrobiodiversity	Dalrymple (1971), Okigbo and Greenland (1976), Minchon *et al.* (1986), Francis (1986, 1988), Landauer and Brazil (1990), Thurston (1992)
Varietal mixtures	Maintains intraspecific crop variability Often reduces damage from pests and diseases favouring maintenance of agrobiodiversity	Clawson (1985); Thurston (1992), Smithson and Lenné (1996), see case studies this chapter
Fallowing and rotation	Maintains soil biodiversity Manages soil pathogens and pests (through interruption of life cycles) favouring crop health and maintenance of agrobiodiversity	Cato (1934), Lewis (1941), Curl (1963), Palti (1981), Thurston (1992), Kennedy (1996)
Organic amendments	Soil enrichment favours soil biodiversity Development of suppressive soils Manages soil pathogens and pests favouring crop health and maintenance of agrobiodiversity	Palti (1981), Cook and Baker (1983), Youtai (1987), Thurston (1992, 1997)
Flooding	Nutrient enrichment favours soil biodiversity Reduces damage from weeds, pests and diseases favouring crop health (especially in paddy rice) and maintenance of agrobiodiversity	Kellman and Cook (1977), Cook and Baker (1983), Thurston (1992), see rice case study this chapter
Burning	Slash/burn systems maintain considerable agrobiodiversity Contributes to pest and disease management, crop health and maintenance of agrobiodiversity	Hardison (1976), Thurston (1992)

Table 1 Part 1 Effects of selected traditional agricultural practices on agrobiodiversity. Original source: (Thurston, 1992), copied from (Thurston H.D. et al., 1999)

Table 9.1. Continued

Traditional practice	Benefits for agrobiodiversity	References
Mulching	Lowers soil temperature, protects against erosion, improves soil texture, provides nutrients and organic matter, reduces weed problems, suppresses soilborne pests and pathogens contributing to crop health and maintenance of agrobiodiversity	Wilken (1987), Thurston (1992)
Raised beds	Improves drainage, fertilization, frost control and irrigation, supports management of soilborne pathogens and pests contributing to crop health and maintenance of agrobiodiversity	Denevan and Turner (1974), Thurston (1992)
Site selection	Avoids diseases, pests and weeds associated with previous crops, matches soil fertility and drainage to crop and variety contributing to crop health and maintenance of agrobiodiversity	Thurston (1992)
Manipulating shade	Maintains biodiversity as interdependent multiple crop variability, e.g. in coffee and cocoa systems	Willey (1975), Thurston (1992)
	Manages pathogens and pests favouring crop health and maintenance of agrobiodiversity	

Table 1 Part 2: Effects of selected traditional agricultural practices on agrobiodiversity. Original source: (Thurston, 1992) copied from (Thurston H.D. et al., 1999)

Both parts of the table give an impression on what can be done related to biodiversity. Of course those management details have to be carefully selected for modern agriculture and where necessary also adapted. But as a catalogue of ideas the table serves well.

There are also comparative data available on long term development, with organic and conventional agriculture, the results show positive trends towards more biodiversity, when conventional farms are changed into organic farms, but the influence of local management habits and also a changing landscape are very important (Taylor, M. E. & Morecroft, 2009).

Another important aspect has been covered by the recently published book of (Gressel, J., 2007) with an interesting theme: A proactive review on orphan crops, their present day deficiencies and how biotechnology methods could greatly enhance them, so that they could be commercialized in future. It is especially fascinating to see how the author is blending modern molecular biology with a deep insight in agriculture and its forgotten crops. This is an important boundary line, where organic/ecological farming can meet and create considerable synergy.

There are a number of books, reports and numerous peer reviewed journal articles which deal in all aspects of ecological agriculture. The authors invited deal with proposals on how to enhance sustainability, how to preserve biodiversity and what can be done so that traditional knowledge with all its treasures does not vanish. There are a majority of authors who really do not lose the focus of the developing world and its dramatic problems, but they avoid topics like modern breeding etc as the example of (Altieri, M. & Nicholls, 2004; Altieri, M. A., 2002; Scherr Sara J. & Jeffrey A. McNeely, 2008). The last one offers highly interesting chapters on the science and practice of ecoagriculture, impressive for the reader to learn about various schemes of integrated farming systems, and some are really integrative and especially strong on the side of analyzing social dynamics, history and economy, topics sometimes forgotten by conservationists and certainly by proponents of high tech agriculture. On the other hand it is striking to see, that with a few notable exceptions, that modern breeding technology and in most cases also high tech management methods like remote sensing, GIS supported systems are not even shortly mentioned. In (Scherr & McNeely, 2008) and the book (Scherr Sara J. & Jeffrey A. McNeely, 2008), in which even a meticulous search does not reveal a single sentence on genetically engineered crops, the otherwise extensive keyword index does not contain such words. On the other hand, it is rewarding to see in the same book a major treatment on remote sensing , stating that remote sensing is an important instrument in the landscape planning of ecoagriculture (GIS-based decision support). Nevertheless, the scarcity of such treatments provokes the serious question about bias against modern agricultural technology. The same can be said from the IAASTD report: In a rebuttal to a letter to Science written by (Mitchell, 2008) attacking the views of (Fedoroff, N., 2008), (Ammann, 2008c) commented about the IAASDD report (IAASTD http://www.agassessment.org/ 2007):

"Mitchell referred to the IAASTD report to degrade the importance of transgenic crops, but this report does not meet scientific review standards and comes to questionable negative conclusions about biotechnology in agriculture: "Information [about GM crops] can be anecdotal and contradictory, and uncertainty on benefits and harms is unavoidable." Such biased judgment ignores thousands of high quality science papers; it is not surprising that most renowned experts left the IAASTD panel before the final report was published".

The good thing about all those publications on ecoagriculture is to see, that transgenic crops and all high tech practices, even the ones of the first generation, could very well fit into ecoagriculture, and vice versa that ecoagricultural strategies could very well be introduced in high tech agriculture: There is a lot of potential in restructuring landscape in regions with a high yielding industrial agricultural production.

As summary and synthesis of both publications, a statement of sustainability is presented. It is, as one can deduct from both texts in New Biotechnology, not written in a defensive way, on the contrary: The view is clear: we can only achieve successfully the goals of sustainability, if we are ready for progress, changing the world, the course of evolution and thus making the best for biodiversity , humanity and our planet.

6. Final remarks about Sustainability

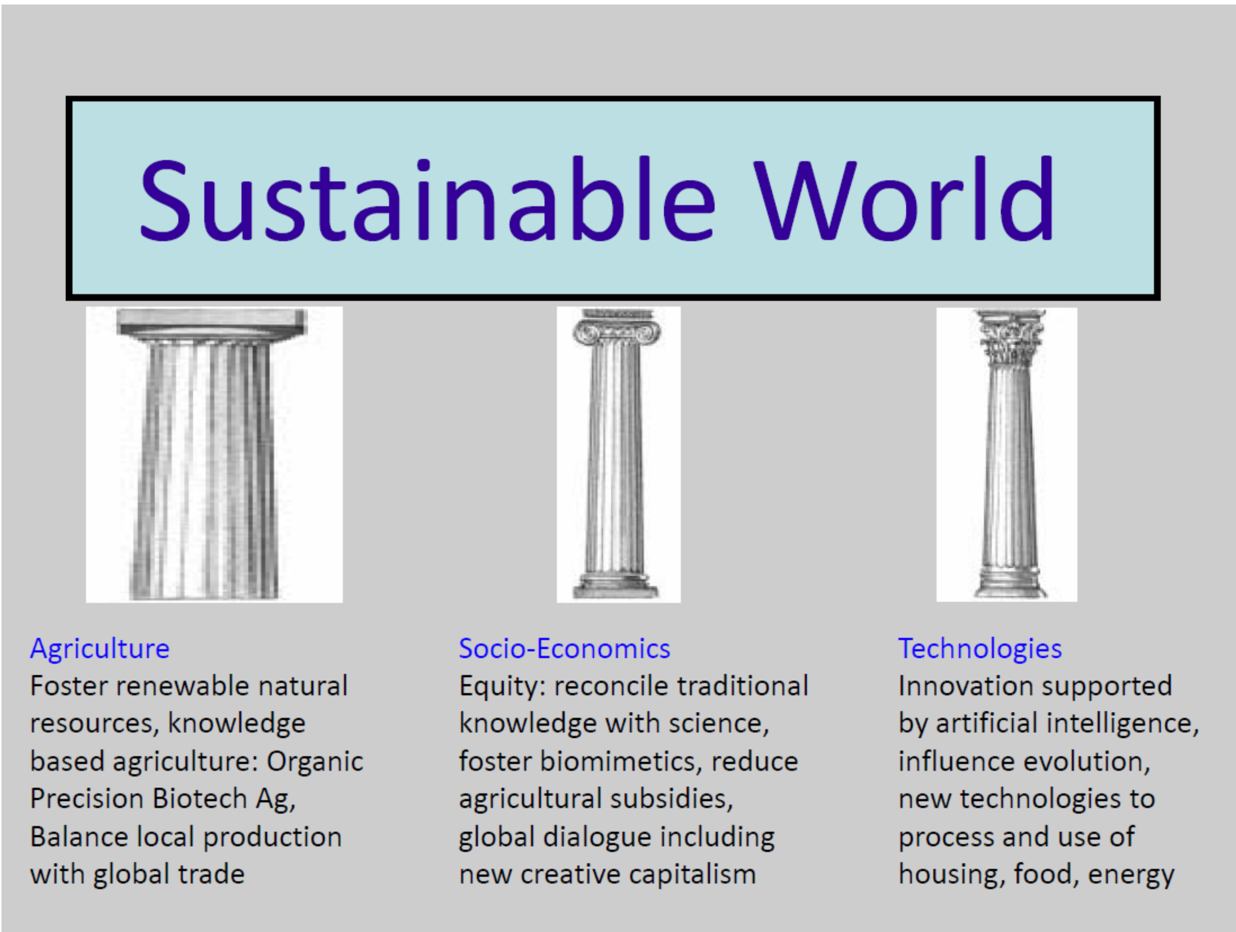

Figure 4 View of a future Sustainable World, original K. Ammann 5.4.2009

If we want to aim at a more sustainable world, it needs more than defensive measures usually advocated by referring to the original definition in the Brundtland Report 1987.

Sustainable development has been defined in many ways, but the most frequently quoted definition is from *Our Common Future*, also known as the Brundtland Report: (UN-Report-Common-Future, 1987)

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- *the concept of **needs**, in particular the essential needs of the world's poor, to which overriding priority should be given; and*
- *the idea of **limitations** imposed by the state of technology and social organization on the environment's ability to meet present and future needs*

Sustainability is usually understood as a definition with a rather defensive spirit, but if one reads it out in its original content, then the words envision uncompromisingly the way forward – asking not only for conservation, but also for *development* and *management* of patterns of *production* and *consumption*.

The declaration of the OECD, authored by Yokoi (Yokoi, 2000) catalogues a range of concrete measures and rules in order to achieve a more sustainable agriculture. It is remarkable, that the proposed indicators do not distinguish between farming with or without transgenic crops.

Our scheme in figure 4 meets those needs and asks for an intransigent view of your future. The three column model has been chosen with care, and as one can see,

- **the most important column to the left is agriculture**, it demands "to foster renewable resources, knowledge based agriculture in the sense of (Trewavas, 2008) and with some additions also in the sense of (Swaminathan, 2001) and (Ammann, 2007a, 2008d). The rather provocative word "Organic Precision Biotechnology Agriculture" is now coined, shorter maybe "organotransgenic" Agriculture, the most elegant "orgenic" is already lost for other purposes. By no means this wants to allude, that the mistakes of organic farming should be included, those mistakes are dealt with properly in my previous article in New Biotechnology (Ammann, 2008d). The most dramatic mistakes are the low yield, documented in many long term monitoring experiments and the eco-imperialist attitude towards farmers of the developing world (Paarlberg, R., 2000, 2009; Paarlberg, R.L., 2001; Paarlberg, R. L., 2002). On the positive side is some pioneering work in developing recycling loops in agriculture (Albihn, 2001; Ernst, 2002; Granstedt, 2000a, 2000b; Kirchmann et al., 2005; Korn, 1996; Srivastava et al., 2004) and also in better landscape management: (Belfrage et al., 2005; Boutin et al., 2008; Clemetsen, M. & J. van Laar, 2000; Dollacker & Rhodes, 2007; Filser et al., 2002; Hadjigeorgiou et al., 2005; Hendriks et al., 2000; Holst, 2001; Jan Stobbelaar & van Mansvelt, 2000; Kuiper, 2000; MacNaeidhe & Culleton, 2000; Norton et al., 2009; Potts Simon G. et al., 2001; Rossi & Nota, 2000; Schellhorn et al., 2008; Skår et al., 2008; Stobbelaar et al., 2000). For more documentation see the previous paragraph on landscape management and organic farming. To balance local production against global trade will not be easy, since the equilibrium between the demands and perils of pressure to produce for global trading and local food production must be found, the economic basis should be important, but local social networking and life need to be taken into account as well.
- **Middle column: Socio-Ethics:** It is of utmost importance to reach more equity, especially in those difficult times of the credit crunch 2009. It will be imperative to reduce agricultural subsidies paid in huge sums to the farmers in the developed world, this kind of protectionism needs to be questioned. Access to global markets is important, but should not hamper local

food production and social structures in the developing world. The myth, that developing countries are in the tight grip of multinationals, can be debunked with some publications: (Atkinson, 2003; Beachy, 2003; Chrispeels, 2000; Cohen, 2005; Cohen & Galinat, 1984; Cohen & Paarlberg, 2004; Dhlamini et al., 2005). A new creative capitalism – a novel discussion which would have been totally utopic before the global economic crisis – needs our attention. It will be a demanding process to reconcile traditional knowledge with modern science, the IP system is up to now completely unilateral, no wonder, it has been created by the developed world. In the IP handbook of Krattiger et al. – it can be accessed over the internet, are numerous contributions offering innovative solutions to reconcile this contrast, also the author contributed and offered some solutions (Ammann, 2006). This contribution made it clear that we need a big boost in breeding science, but also a new focus on emerging fields in science: biomimetics (formerly bionics) could be a promising field of research, where high tech equipment is certainly helpful, but not indispensable, and agriculture needs new research goals for new production lines. Hygroscopical mechanisms are offered in the plant kingdom and also abundantly with insects, but the details of those mechanism, often functioning for 200 years beyond the organismal death, needs clarification, and maybe some future day we would be able to use the adiabatic moisture differences of our daily climate fluctuations to produce power.

- **Left column on evolution:** The most audacious third column questions our view of Evolution in the biological and in the general sense of the word. Evolution deplorably still contains – often not conscious – some elements of creationism – and this not only with opponents of gene splicing. It will be important to emancipate these views and make clear, that since many years we have taken human evolution in our own hands through modern medicine, and we need to deal with the problems *AND* prospects of a new evolutionary view. Genetic engineering has the potential to enlighten the population, if done in an ethically acceptable way and if communicated properly. The tasks will grow over the decades, and in many fields of science we are already now heavily dependent on calculation power, let's make sure that mathematical algorithms can be translated into useful artificial intelligence in the service of mankind. We need the help of all new and emerging technologies (of course regulated in a sensible way) in order to enhance food production and the lifelyhood of mankind. The statement "only one planet" is at the same time a reminder to precaution, but also to our responsibility to take evolution as a whole in our own hands.

Some closing words: Agriculture is in the center of this text, rightly so, since we have the urgent task to feed 800 million hungry people, and there is no time for sterile sophisticated bickering on whether some hypothetical negative effects in a hundred years could emerge. Since, until then hundreds of millions of people will die from hunger and diseases. The case of the golden rice is symbolic for the situation of mankind: We can develop it as fast as we can, unhampered by over-regulation – or we may tolerate hundreds of thousands of children dying every year from pro-vitamin A deficiency, it is no coincidence that this article closes with some references essential for the Golden Rice debate: (Depee et al., 1995; Humphrey et al., 1998; Humphrey et al., 1992; Mayer et al., 2008; Potrykus, 2003; Stein et al., 2008). After all, human beings should be part of any risk assessment in technology, this is a request with enormous ethical implications.

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