Parameters for Apple Quality-2

and the development of the ‘inner quality concept’

2001 - 2003

met Nederlandse samenvatting: Parameters voor appelkwaliteit en de verdere ontwikkeling van het ‘innerlijke kwaliteitsconcept’, 2001-2003.

mit deutscher Zusammenfassung: Parametern für Apfelqualität und die weitere Entwicklung des Begriffs der ‘Inneren Qualität’, 2001-2003.

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International Research Association for Organic Food Quality and Health – Association of research institutes and stakeholders, that aims to stimulate research in the field of organic food quality and health, to present publications, and to organise scientific conferences and exhibitions.
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1.1 English summary and conclusions

Parameters for apple quality and the development of the 'Inner Quality Concept' 2001-2003

Joke Bloksma, Martin Northolt, Machteld Huber, Pieterjans Jansonius, Marleen Zanen, Louis Bolk Instituut, 2004.

....
In the palm of his hand he holds all the sections,
Lacks nothing, except the spirit's connections.
Goethe in Faust

Motivation

Public interest for inner quality aspects

Many organically grown products have won the acclaim of the best chefs. Growers know that good taste depends on moderate fertilisation and yields, careful ripening and freshness. The need to keep costs down, especially in conventional production but increasingly so in the organic sector as well, has however prompted concessions to be made with respect to inner quality. In an effort to cut the cost price, organic agriculture, too, is moving in the direction of higher yields, higher fertilisation levels, earlier harvests and trade chains involving lengthy journeys and extended storage. Farmers, growers and wholesalers are exploring the extent to which they can realise these economies without damaging the good level of inner quality of the products.

Also new questions have been raised about the pros and cons of genetic modification in the breeding and propagation of cultivars: Are genetically modified varieties less 'coherent', and if so, is this disadvantageous for health? Do food crops with enriched levels of vitamins or phenols enhance health? What do coherence, structure and ripeness, or typical characteristics mean in terms of taste and consumer health? These questions need to be answered.
Food quality is more than the sum of exterior characteristics, a few distinct component substances and the absence of harmful contaminants. We need to develop a new quality concept for food products. In order to satisfy today's consumers, organic and conventional production and supply chains must both respond to this demand.

Cooperation in the international association for organic Food Quality and Health (FQH)

The international research association Organic Food Quality and Health (FQH) was established to promote research into the health effects of good quality organic food. This type of research requires a coherent concept of quality with empirical parameters and a research methodology for measuring health effects. The research presented in this report thus serves the long-term research objective of FQH.

The first step was to define quality and to develop parameters to measure the different aspects of quality. To this end, we introduced the provisional concept of 'vital quality' in the first apple study. In the second apple study, this concept was further developed to 'inner quality'. A similar study has meanwhile been launched for carrots. Quality needs to be defined and measurable before the next question can be investigated, i.e. whether products with a high degree of 'inner quality' are indeed healthier for people, or certain groups of people.

Partners and financiers

Our partners in the second apple project were: Orchard ter Linde in Oostkapelle (NL), Kwalis Qualitätsforschung Fulda (D), Meluna Bio-photon research in Geldermalsen (NL), Elektro-chemisches Qualitäts labor, Weidenbach (D), Biodynamic Research Association Denmark (DK) and Louis Bolk Instituut in Driebergen (NL). In addition, we employed the services of many other parties.
The project was financially supported by Orchard ter Linde (NL), Triodos Fund Foundation (NL), Rabobank (NL), Software AG Stiftung (D), Zukunftsstiftung Landwirtschaft (D), Meluna (NL), Kwalis Qualitätsforschung (D) and the internal project fund of Louis Bolk Instituut (NL).

New terms in the quality concept since the first apple study

The term vitality, used in the first apple study, raised considerable confusion, despite having been clearly described as the result of growth processes, and was therefore abandoned. For the same reason, the general term 'vital quality' was replaced with 'inner quality'.

It was difficult to find suitable generic terms for the product characteristics of growth, differentiation and integration, which would apply to all products. The use of the term 'structure' for the result of differentiation and the term 'coherence' for the result of integration was found to be inadequate for some products. We therefore preferred to select product characteristics for each product. For apple, for example, big size and crispness are the results of relatively strong growth processes, yellow fruit ground colour are the results of relatively strong differentiation processes, while sweetness and aroma are the result of integration processes.

What is 'Inner Quality'?

'Inner Quality' is an extension of existing quality criteria on shape and exterior, on the presence of desired and undesired substances, and on hygienic standards. Inner Quality refers to those characteristics which together result in a crop-specific product that is ripe, tasty and has satisfactory keeping quality. These characteristics develop as the crop grows, and result from the continuous interaction between growth and differentiation processes. Growers can direct these processes as desired using different crop management measures. A similar concept may be developed in the future for products of animal origin.

A Concept for Inner Quality

A coherent quality concept appropriate for living products

A quality concept must fulfil various requirements. It must of course tie in with growers' practices, regardless of whether they are organic or conventional. It is, after all, the grower who nurtures the life processes in crops or livestock. It is possible to distinguish growth processes and differentiation processes, and these processes can occur in varying proportions and degrees of mutual interaction (integration).

A quality concept should also establish a link between consumers' perception of product quality in the store and growers' perception of their crops. This will enable the grower to make adjustments in the course of the growing season, taking advantage of seasonal and soil variations, to realise optimum quality in the end product. Consumers' wishes are never uniform: their food preferences depend on individual preferences, on their health and mood. There is a market for produce with different good qualities, just as there are people who like tart, crisp long-keeping apples while others prefer soft, sweet, aromatic apples. These different accentuations can be realised in the growing season. So there is no one optimal quality for everyone. The quality concept presented in table 1a therefore consists of three interlinked dimensions: crop management, processes and properties.

Methodology

The second apple study is part of the FQH related research programme of Louis Bolk Instituut to design and evaluate a new quality concept. The first apple study primarily concerned the design of the quality concept, and also examined growth and differentiation processes and investigated how these may be measured. In this second apple study, we designed a course of validation for the concept, and executed this in part. We also approached growers and researchers of other crops to determine whether they could subscribe to the concept and the two life processes and their integration (*face validity and content validity*). They did agree on the concepts of growth and differentiation. Some examples were published in a brochure on life processes in food crops (*Life processes in crops*, Bloksma and Huber, 2002). Difficulties arose with the concept of integration and the term vitality, and we worked on improving these. We have taken a new course in distinguishing the processes of growth and differentiation per organ (fruit, blossom, shoot) and establishing development in relation to the course of the year. We scrapped plant hormones as an aspect of growth processes.

We checked the *consistency of the theoretical construct* by comparing the quality concept with various hypotheses and results from the literature. The concept agreed well, for example, with the growth-differentiation-balance hypothesis used in plant ecology research into resistance to pests and diseases. We hope to be able to continue our study of the literature as regards the concept of integration in the future.

Table 1a: The renewed concept for 'Inner Quality' for apple, based on this study, literature and growers' experience (? = still uncertain)

Inner Quality for apple		
CROP MANAGEMENT to regulate the growing crop *to communicate with the grower*	**PROCESSES** in the crop *to communicate with the grower*	**PROPERTIES** of the crop or the final product *to communicate with the grower, consumer and retailer*
1. Growth		
+ no limits in nutrients and water by optimal fertilising and watering + defruiting when heavy bearing + growth stimulating pruning + space (wide plant distance) – root pruning, trunk notching – controlled drought stress – growth reducing pruning	• photosynthesis: primary metabolites (C-growth) • nitrogen (and other nutrients) uptake (N-growth) • filling reserves with starch, protein, etc • forming mass • maintenance of basic metabolism	• green vegetative mass, leaf size, tree vigour, fruit size, fruit weight, yield • acid, starch • amino acids, protein • firmness, juiciness, crispness • metabolic energy • many fungal diseases and sucking insects (aphid) • a high initial value in delayed luminescence • perradation, fullness, expansion in CC-crystallisation pictures
2. Differentiation		
+ light and dry warm growing place + reducing heavy growth + binding down young twigs + hormone ethylene + beehives for pollination	• refining, ordering • ripening: starch -> sugars; acid -> aroma • secundary metabolism • induction of pollen, seeds and flower buds	• differentiated refined forms (leaf serrations, cork) • order • calcium, firm cell walls • ethylen (=ripening hormone) • ripe colours (yellow ground on fruit, autumn leaves) • biting insects (blossom weevil, etc) and powdery mildew • hyperbolic decay in delayed luminescence • structure in CC-crystallisation pictures
1+2 Integration		
+ growing phase-typical care for optimal proportion between growth AND differentiation + balanced nutrients, regular and slow release of nutrients (compost) + appropriate varieties + diseases preventing soil (by compost?) + diversity? + human attention? + harmonious landscape? + Biodynamic preparations?	• interaction between growth and differentiation in a species and stage balance = 'maturing' • forming sec. metabolites out of primary metabolites. • self-regulating	• species-and stage-typical proportion of growth and differentiation properties = 'maturation' • tasty and red, glossy fruits = aroma + blush + shine + firmness + juiciness + sweetness • high number of fertile generative organs (flower buds, seeds) • phenols, vitamin C, tannin, wax, resin • high ratio protein / total nitrogen • self-regulation, elasticity, cell turgor, resistance to stress and diseases • wound healing after damage • species-typical in spectral range luminescence • coherence in CC-crystallisation pictures

There is a risk of using circular reasoning when introducing a new quality definition with experimental parameters. After all, it is difficult to introduce an unknown concept (in this case, integration) with unknown crop management measures (such as biodynamic preparations) and to measure it with experimental parameters. Experimental parameters may correlate with established parameters (*convergent validity*), such as resistance to disease and evaluation of taste. In that case, the experimental parameters offer no added value and the parameter which is least expensive to implement may be chosen. On the other hand, there may be no correlation and this would suggest that new aspects of quality have been found. Understanding might then be achieved by simultaneously working on the theoretical foundations of the new concept and executing experimental series to evaluate the concept. By logical reasoning, a new concept such as integration might be derived from known plant physiology concepts (in this case, growth and differentiation and, for example, self-regulation). This is known as *construct validity*. The new concept may then be evaluated by comparing the actual results of experimental crop management measures with the expected results.

Life processes play a crucial role in this methodology: they provide the conceptual coherence and the handholds of the quality concept. 'Inner quality' can be deemed to be a meaningful concept that may be objectively measured when the experimental concepts, the implemented crop management measures and the measured parameters are found to be consistent and practically feasible over a period of several years (*predictive validity*). The aim of this second apple study is two-fold: pursuing further conceptual argumentation of the quality concept and conducting follow-up experimental trials on apples.

Design of the second apple experiment

Apples were chosen as our experimental crop for the development of the quality concept because considerable knowledge already exists about the inner quality aspects of apples. In addition, concepts such as growth and differentiation are commonly used by fruit growers. They acknowledge these terms and can take appropriate measures to regulate these. The downside of using apple as our experimental crop is that the apple tree is a complex organism with different organs (shoot, fruit, bud, root, trunk) which grow and differentiate in different stages. The study design reflected this complexity and subsequently it was not easy to draw conclusions from the study results. The comprehensive body of knowledge from conventional circles was used as a reference frame for evaluating the new experimental quality parameters and the new terms. The theoretical study into the quality concept was designed such that some practical questions from the orchardist involved could be answered, too.

In the first apple experiment, which took place in the same orchard, we used graduated reference series with small variations in growth and differentiation. The series were: duration of ripening, yield, sunlight exposure and post-harvest ageing.
New series were added in the second apple study in order to explore the concept of integration more extensively. One was a fertilisation series to explore the influence of fertilisation on the dynamic relationship between growth and differentiation. The second series was a dichotomous series of use or non-use of biodynamic field preparations. Two aspects are involved in integration, namely the ratio and the degree of interaction between growth and differentiation. The aim of the fertilisation series was to explore the proportional relationship between these aspects, while we expected that the biodynamic field preparations would enhance the interaction between growth and differentiation.

In the orchard, the biodynamic preparations were laid out in duplicate, resulting in four blocks. Within each block, there was one fertilisation series made up of six different plots holding ten trees each: one plot was unfertilised, four had different dressings of commercial fertiliser and one received a dressing of semi-composted farmyard manure.
With respect to the last, we assumed that compost would influence and possibly improve the interaction between growth and differentiation. In each series, fertilisation regimes were assigned randomly to the plots. Thus we obtained two complete fertilisation series in which biodynamic field preparations were applied and two complete fertilisation series in which no biodynamic field preparations were used.

The experimental conditions were controlled for homogeneity of the plot (minor differences in soil type), differences in speed of ripening (not found), equal bearing (found) and availability of standard fruits for assessment (70 to 90 mm in diameter, unblemished, picked from medium height on representative trees, situated in a sunny or partly sunny spot).

It takes time for fertilisers to take effect in perennial crops, so we decided to implement the different fertilisation regimes for three years and to make a general assessment of the crop over three years, too. A detailed evaluation of the crop and the quality of the apples was conducted only in the second year, on the basis of 80 standard fruits picked from each plot. These were distributed for analysis to the different participating laboratories.

Conclusions applying to this orchard

The effect of different levels of fertilisation

Fruit growers wanted to know the optimum fertilisation regime for a high, regular yield and good fruit quality. In terms of the quality concept, we wanted to know whether the level of fertilisation effects a shift in the proportionate relationship between growth and differentiation.

The fertilisation regimes were carried out each year in the spring. A combination of two commercially available fertilisers was used. The first, Maltaflor, is made of the waste products of conventional sugar and beer production and contains nutrients which are released very quickly. The second commercial fertiliser was organic poultry manure in pellet form, which nutrients released slightly less rapidly. The incremental steps in the fertilisation series, expressed in kilograms of nitrogen per hectare, were: 0, 40, 80, 120 and 160. This gradation applied to all nutrients but here we have distinguished them only in terms of nitrogen, since nitrogen was the limiting mineral for this orchard.

After one to two years, these fairly large differences in fertilisation had only resulted in relatively small differences in trees and apples. After two to three years it had become clear that the 0 kg N / ha and 40 kg N / ha regimes were inadequate (the trees had a non-bearing year) and that fertilising with 160 kg N / ha was too much of a good thing (poor fruit quality). As expected, higher fertilisation stimulated growth characteristics and caused a decline in differentiation characteristics: there was a longer period of shoot growth and there were more shoots, but there were also more fungal infections, darker and larger leaves, higher nitrogen levels in the bud, leaf and fruit, and more and stronger blossom formation for the following year. Higher levels of fertilisation yielded larger apples which were less firm and slightly less tart, with less blush, a lower phenol content and a greater susceptibility to fruit rot.

For this site, a fertilisation regime of about 100 kg N / ha best realised the two-fold objective of regular yield and good inner quality. The trees were 12-year-old Elstars, a variety which is susceptible to non-bearing years, growing on weak root stocks (M9, 2460 trees / ha). The soil fixed nitrogen easily. In this orchard, it should be possible to achieve a regular yield of about 40 tonnes per hectare under organic conditions. In addition to using the optimum fertilisation regime, it is necessary to defruit on time, to water the trees in dry periods, and to prevent competition from weeds, frost damage, diseases and pests.

The effect of compost versus commercial fertilisers

Fruit growers asked us what would be the best fertiliser for a biodynamic orchard. In terms of the quality concept, we wanted to know if compost dressings would result in greater integration. In addition to the fertilisation regimes above, we included an additional regime of semi-composted farmyard manure (100 kg N / ha) applied in spring. We hypothesised that the nutrients in compost are released slowly over a longer period of time, in contrast with the commercial fertilisers used in our study which release most nutrients early in the year. We expected that the rapid availability of nutrients in spring would however better suit the requirements of the tree, and that commercial fertilisers would be easier to apply. Another advantage of commercial fertilisers is that orchardists are not dependent on adequate availability of local manure production.

In our study, we found that compost application had distinct benefits for the soil in comparison with commercial fertilisers. In particular, we found an increase in soil organisms and accelerated leaf decomposition. In the first year or two, the effects of compost application on the trees and fruit characteristics were similar to those of the non-fertilisation regime. In the longer term (after two to three years of application) the effects were comparable to the results found on plots with moderate commercial fertiliser applications. Comparing compost and commercial fertiliser dressings both provide 100 kg N / ha, we may state that the nutrients in compost tend to benefit soil fertility most while the nutrients in commercial fertilisers benefit the tree most. Although the differences were small, we concluded that when using compost a greater quantity of nitrogen per hectare must be applied so that the nutrient requirements of both soil and trees are fulfilled. For best results in practice, compost and commercial fertilisers could be applied in combination.

After two to three years of applying these different fertilisation regimes, we found no differences in the trees or fruits which could be attributed to different rates or patterns of nutrient release, nor did we find any indication that compost leads to better integration, besides an inclination in one of the two testing panels to give a higher assessment of taste.

The effect of biodynamic field preparations

Fruit growers wanted to know if the effect of biodynamic field preparations could be made more visible for themselves and for consumers. In terms of the quality concept, we wanted to know if the use of biodynamic field preparations resulted in greater integration.

For our trial, we mapped out two biodynamic series, i.e. a total of four blocks measuring 33 by 50 square metres. Over a period of two years, the application of biodynamic field preparations was stopped on two blocks, while their use was continued on the other two blocks and in the surrounding orchard. Since the effects of this management measure are not clearly established, we did not know whether the period of two years without would be sufficient after 80 years of application, nor did we know whether the distance between treated and untreated plots was sufficient, or whether the application frequency (about 8 times a year) was effective.

We found a significantly higher rate of leaf decomposition in treated plots, which could not be explained by other factors. As for most other differences observed, these could also be attributed to soil differences. Only two series with biodynamic preparations could be mapped in this orchard and the differences for most parameters were small. Plots treated with biodynamic preparations had the following characteristics: greater reserves of phosphor and potassium in the soil and the fruit, higher calcium content in the leaf, more fruit rot and scab after storage, a tendency towards higher assessment of taste, more differentiation and integration in the copper chloride crystallisations (=CC-crystallisations) and a different luminescence value.

It remains difficult to establish, methodically, the effect of a measure which needs to be applied over large areas. Statistical significance of the results could not be calculated because these series only had two independent repetitions and differences in soil conditions. Effects can only be established with certainty by conducting multiple trials which show similar tendencies.

Conclusions regarding the development of the quality concept

We found clear correlations between management measures, tree characteristics and fruit characteristics. This means that growers can regulate apple quality during the growing season. On the basis of the two apple experiments, we can distinguish respective sets of growth and differentiation parameters and evaluate them in the light of conventional fruit cultivation science. Our results have little new value for fruit growing in practice, however. The value of our research lies in the approach developed to draw up a quality concept and the way in which we can apply this concept to crops about which little knowledge exists regarding the relationship between management measures, crop characteristics and product quality characteristics. Our research also offers a method to validate experimental parameters.

Identifying parameters

Table 1a lists the management measures, physiological processes and product characteristics found in the literature and proposed by growers on the basis of their own experiences. The parameters below were confirmed by our apple experiments.

Growth

The parameters of tree growth are: fruit-bearing (on condition of equal shoot growth and bearing in previous year), shoot growth (combination of number of shoots, shoot length, termination of shoot growth and on condition of equal bearing), leaf size or colour (on condition of equal shoot growth), nitrogen content in bud, nitrogen and magnesium contents in leaf, and scab infestation.
The parameters of fruit growth are: fruit size or weight (on condition of same bearing), firmness (on condition of

equal bearing and shoot growth), acidity, nitrogen content, amino acid content, protein content, tart and crisp taste, growth score on copper chloride crystallisation images, high initial delayed luminescence, susceptibility to fruit rot.

Differentiation

Parameters of tree differentiation are: autumn colours and bud formation (on condition of equal bearing). Parameters of fruit differentiation are: hue of blush, yellow ground colour, shape of fruit, sheen, starch conversion, differentiation score on copper chloride crystallisation images, hyperbolic decline of photons (Meluna, Kwalis).

Growth and differentiation

For most plant processes, both growth and differentiation are important. Many parameters can therefore express both growth and differentiation, depending on which is the limiting factor. For example, bud formation is a parameter of growth when fertilisation is the limiting factor. If the limiting factor is sunlight exposure, bud formation acts as a differentiation parameter in a light exposure series. Another example of parameters which express both growth and differentiation is the content of secondary metabolites in the plant, such as phenols, vitamins, aromas and the red colouring agents of fruit. The formation of the raw material (assimilates) is a growth process; the subsequent conversion to secondary metabolites is a differentiation process. A correlation with either growth or differentiation is found depending on when the measurements were taken and what the limiting factors are.

Integration

There are parameters which could potentially give an indication of the degree of integration. These are: resistance to diseases and pests, overall taste, phenols, ratio of proteins to free amino acids, integration score on copper chloride crystallisation images, species-specific colour ratio in spectral range luminescence (Kwalis). Universally accepted measurement methods exist for the first three, the last three have only recently been validated for carrots and wheat. The last results obtained do not yet allow clear interpretations as regards the assessment of quality. To this end, the quality concept must provide a context for these measures, and still more reference series, as used in the two apple studies, must be established.

Copper chloride crystallisations and spectral range luminescence dovetail well with the quality concept since both techniques can be evaluated on all three aspects: growth, differentiation and integration. This study produced a successful growth series, and for both techniques we found that the growth aspect correlated with many universally accepted growth parameters. Unfortunately, in this study there was too much variation in electro-chemical measurements to be able to establish differences between treatments.

Recommendations for future research

Further research is necessary to validate the quality concept. Our suggestions are listed below.

- The integration concept and its management measures need to be substantiated in plant physiological terms, so that integration experiments may be designed for apple and other crops.
- Experimental series need to be carried out for other crops than apple and carrot. Such experiments should fulfil the following requirements:
  - a simple crop with a limited number of organs;
  - serial implementation of management measures, with gradual changes in one factor, from too low to too high, while other factors remain constant;
  - diseases and pests should not be prevented and eradicated after the young stage, as degree of resistance is an important integration parameter.
- The inner quality concept needs to be reviewed more extensively in the context of other quality concepts.
- The relationship between the quality concept and human or animal health needs to be established from a holistic perspective on health. This should be followed by health care research.

1.2 Nederlandse samenvatting en conclusies

Parameters voor appelkwaliteit en de ontwikkeling van het 'Innerlijke Kwaliteitsconcept' 2001-2003.

Joke Bloksma, Martin Northolt, Machteld Huber, Pieterjans Jansonius, Marleen Zanen, Louis Bolk Instituut, 2004.

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Dan heeft hij alle delen in zijn hand,
Ontbreekt echter, de geestelijke band.
Goethe in Faust

Aanleiding

Maatschappelijke interesse voor innerlijke kwaliteitsaspecten

Veel biologisch geteelde producten werden geroemd om hun goede smaak door topkoks. Telers weten dat voor een goede smaak een niet al te hoog productieniveau, een matige bemesting, zorgvuldige rijping en versheid van belang zijn. Vooral in de gangbare landbouw, maar nu ook in toenemende mate in de biologische landbouw, staat de kostprijs zo onder druk dat concessies gedaan worden ten aanzien van de innerlijke kwaliteit. Ook de biologische landbouw wil hogere opbrengsten, gaat meer bemesten, oogst op een vroeger tijdstip en maakt gebruik van handelsketens met langdurig transport en opslag om de kostprijs te drukken. Boeren, tuinders en handelaren zijn op zoek hoe ver ze kunnen gaan met deze kostprijsverlaging, zonder afbreuk te doen aan de goede innerlijke kwaliteit van de producten.

Tevens zijn bij de veredeling van landbouwgewassen vragen gerezen over de voor- en nadelen van genetische modificatie. Is het zo dat genetisch gemodificeerde gewassen minder 'samenhang' vertonen en zo ja, is dit ongunstig voor de gezondheid? Is het een voordeel voor de gezondheid om gewassen te veredelen met extra hoge gehaltes vitaminen of fenolen? Welke betekenis heeft samenhang, structuur en rijpheid, of product-typiciteit voor smaak en voor de gezondheid van de consument? Dit zijn de soort vragen waarop een antwoord wordt gezocht. Voedselkwaliteit moet niet beperkt worden tot een beoordeling van uiterlijk, enkele afzonderlijke inhoudstoffen en de afwezigheid van ongewenste contaminanten. Daarom is een nieuw kwaliteitsconcept voor voedingsgewassen nodig. Dit vraagstuk is voor zowel de biologische als voor de gangbare handelsketens uiterst actueel om hun consumenten te bedienen.

Samenwerking binnen de internationale vereniging 'organic Food, Quality and Health'

De internationale onderzoeksvereniging 'organic Food, Quality and Health' (FQH) is opgericht om onderzoek te bevorderen naar de gezondheidseffecten van biologisch voedsel van goede kwaliteit. Daartoe is een samenhangend kwaliteitsbegrip nodig met toetsbare parameters en onderzoeksmethodieken om gezondheidseffecten te meten. Dit lange termijn doel is de context van het hier gepresenteerde onderzoek.
De eerste stap is het ontwikkelen van kwaliteitsbegrippen en parameters om verschillende aspecten van kwaliteit te meten. Hiervoor is het voorlopige concept van de 'vitale kwaliteit' geïntroduceerd in het eerste appelonderzoek. In dit tweede appelonderzoek is dit concept verder ontwikkeld tot 'innerlijke kwaliteit'. Inmiddels is ook een vergelijkbare opzet van onderzoek naar wortel in uitvoering. Als de kwaliteit omschreven en meetbaar is, is pas de volgende stap mogelijk, namelijk het toetsen of producten met een hoge 'innerlijke kwaliteit' inderdaad gezonder zijn voor (bepaalde groepen) mensen.

Partners en financiers

Partners in dit tweede appelproject waren: Boomgaard ter Linde in Oostkapelle (NL), Kwalis Qualitätsforschung Fulda (D), Meluna Bio-fotonen onderzoek in Geldermalsen (NL), Elektro-chemisches Qualitäts labor, Weidenbach (D), Biodynamic Research Association Denemarken (DK) en het Louis Bolk Instituut in Driebergen (NL). Daarnaast hebben we nog gebruik gemaakt van de diensten van vele anderen.
Het project is financiëel mogelijk gemaakt door Boomgaard ter Linde (NL), Stichting Triodos Fonds (NL), Rabobank (NL), Software AG Stiftung (D), Zukunftsstiftung Landwirtschaft (D), Meluna (NL), Kwalis Qualitätsforschung (D)

en het interne projectenfonds van het Louis Bolk Instituut (NL).

Concept voor Innerlijke kwaliteit

Samenhangend kwaliteitsconcept passend bij levende producten

Er zijn verschillende eisen opgesteld, waaraan een kwaliteitsconcept moet voldoen. Het moet aansluiten bij hoe een (biologische) teler werkt: hij of zij verzorgt levensprocessen in het gewas of dier. Hier zijn groeiprocessen en differentiatieprocessen te onderscheiden, en deze kunnen in verschillende verhouding en onderlinge samenwerking optreden (integratie).
Het kwaliteitsconcept moet ook een verbinding leggen tussen hoe consumenten naar de kwaliteit van het product in de winkel kijken en hoe telers naar hun gewassen kijken. Dit maakt het mogelijk dat de teler tijdens de teelt kan bij sturen naar een optimale kwaliteit van het eindproduct, inspelend op de variatie door elk seizoen en elke grondsoort. Consumenten hebben geen uniforme wensen; zij zullen voorkeur hebben voor voedsel afhankelijk van individuele voorkeur, gezondheid en gemoedstoestand. Er is een markt voor verschillende goede kwaliteiten, zoals een lang houdbare, frisse, knapperige appels naast zachte, zoete, aromatische appels. In de teelt kunnen zulke accenten al gelegd worden. De optimale kwaliteit is dus niet voor iedereen hetzelfde. In het kwaliteitsconcept (tabel 1b) zijn daarom 3 kolommen, die de relatie leggen tussen de teeltmaatregelen, de levensprocessen en de producteigenschappen.

Nieuwe termen in het kwaliteitsconcept sinds het vorige appelrapport

Het begrip vitaliteit, zoals gebruikt in het eerste appel project, gaf veel verwarring, ook al was vitaliteit in het eerste appelonderzoek eenduidig omschreven als het resultaat van groeiprocessen, zodat deze term is losgelaten. Om deze reden is ook de overall term ‘vitale kwaliteit’ vervangen door ‘innerlijke kwaliteit.
Het was lastig om termen te vinden voor de producteigenschappen van groei, differentiatie en integratie, die voor alle producten gelden. ‘Structuur’ als resultaat van differentiatie en en ‘samenhang’ als resultaat van integratie dekken het begrip niet goed voor alle producten. Daarom kiezen we bij voorkeur de producteigenschappen per product. Voor appel is bijvoorbeeld groot en knapperig het resultaat van relatief sterke groeiprocessen, gele grondkleur zijn het resultaat van relatief sterke differentiatieprocessen en zoet en aromatisch het resultaat van integratie.

Wat is ‘innerlijke kwaliteit’ ?

‘Innerlijke kwaliteit’ is een uitbreiding van bestaande kwaliteitscriteria aangaande vorm en uiterlijk, gewenste en ongewenste inhoudsstoffen en afwezigheid van ziektekiemen. Het gaat bij 'Innerlijke kwaliteit' om die eigenschappen, die met elkaar tot een gewas-kenmerkend, gerijpt, smakelijk en voldoende houdbaar product leiden. Deze eigenschappen ontstaan tijdens de ontwikkeling van het gewas door een voortdurend samenspel van groei- en differentiatieprocessen, die door teelthandelingen van de teler kunnen worden bijgestuurd. Voor dierlijke producten is in de toekomst een vergelijkbaar begrip op te stellen.

Methodologie

Dit tweede appelonderzoek is een onderdeel van het werk van het Louis Bolk Instituut, in het kader van de FQH-vereniging, om een nieuw kwaliteitsconcept te ontwerpen en te toetsen. In het eerste appelonderzoek lag de nadruk op het ontwerp van het kwaliteitsconcept, op groei- en differentiatieprocessen en hoe deze te meten zijn. In dit tweede appelproject is een validatie-route ontworpen voor het concept, en hiervan is een deel uitgevoerd. Bij telers en onderzoekers van andere gewassen is nagegaan of het concept en de twee levensprocessen en hun integratie herkend worden (*face validity en content validity*). Dit was het geval voor de begrippen groei en differentiatie. Een aantal voorbeelden zijn gepubliceerd in de brochure ‘Levensprocessen in voedingsgewassen’ (Bloksma and Huber, 2002). Het begrip ‘integratie’ en de term ‘vitaliteit’ bleken problematisch en hier is aan verder gewerkt. Nieuw is dat we de processen groei en differentiatie onderscheiden per orgaan (vrucht, bloem, scheut) en de ontwikkeling plaatsen in het jaarverloop. Het noemen van plantenhormonen bij groeiprocessen is geschrapt.
Het kwaliteitconcept is vergeleken met een aantal hypothesen en resultaten uit literatuur (*consistency of the theoretical construct*). Dit concept sluit bijvoorbeeld goed aan bij de growth-differentiation-balance-hypothese uit het plantenecologisch onderzoek naar weerstand tegen ziekten en plagen. Het literatuuronderzoek moet nog verder worden voortgezet voor integratie.

***Tabel 1b**: Het vernieuwde concept voor 'Innerlijke kwaliteit' voor appel op basis van dit onderzoek, literatuur en ervaringen van telers (?= nog onzeker).*

Innerlijke Kwaliteit bij appels		
TEELTMAATREGELEN om het gewas tijdens de teelt 'bij te sturen' *in gesprek met de teler*	**PROCESSEN** in het gewas *in gesprek met de teler*	**EIGENSCHAPPEN** van het gewas of het eindproduct *in gesprek met teler, consument en handelaar*
1. Groei		
+ geen beperking in voedingsstoffen en water door optimale bemesting en watergift + vruchtdunnen bij hoge dracht + groeistimulerende snoei + ruimte (wijde plant-afstand) – wortelsnoei, inzagen van de stam – gecontroleerde droogtestress. – groeiremmende snoei	• photosynthese: primaire metabolieten (C-groei) • stikstof (en andere voedingsstoffen) opname (N-groei) • vullen van de reserve organen met zetmeel, eiwit, etc • massa vorming • onderhoud (basis stofwisseling)	• groene vegetatieve massa, bladgrootte, scheutgroei, vruchtgrootte, vruchtgewicht, opbrengst • zuur, zetmeel • aminozuren, eiwit • hardheid, sappigheid, knapperigheid. • metabolische energie • diverse schimmelziekten en zuigende insecten (bladluizen) • hoge aanvangswaarde bij biofotonen • expansie, vertakking en gevuldheid in CC-crystallisatie beelden
2. Differentiatie		
+ lichte en warme groeiplaats + beperking van groei + jonge takken uitbuigen + hormoon ethyleen + bijenkasten voor extra bestuiving	• verfijning, ordening • rijping: zetmeel -> suikers; zuur -> aroma • secundair metabolisme • inductie van stuifmeel, zaden en bloemknoppen	• gedifferentieerde, fijne vormen (bladtandjes, kurk) • orde • calcium, stevige celwanden • ethyleen (=rijpingshormoon) • rijpe kleur (gele grondkleur op fruit, herfstkleuren op blad) • bijtende insecten (bloesemkever, etc) en echte meeldauw • hyperbolische afname van biofotonen • structuur in CC-crystallisatie beelden
1+2 Integratie		
+ zorg voor optimale verhouding tussen groei en differentiatie in elk groeistadium + voedingstoffen in goede verhouding en regelmaat in vrijkomen (compost) + passende rassen + ziektewerende bodem (door compost?) + diversiteit? + menselijke aandacht? + harmonieus landschap? + biologisch-dynamische preparaten?	• samenwerking tussen groei en differentiatie in een verhouding die past bij soort en groeistadium • vorming van secundaire metabolieten uit primaire metabolieten • zelfregulatie	• bij soort en groeistadium passende verhouding tussen groei en differentiatie kenmerken • smakelijke en rood glanzende vruchten = aroma + blos + glans + hardheid + sappigheid + zoetheid • veel vruchtbare, generatieve organen (pitten, bloemknoppen) • fenolen, vitamine C, tannine, was, hars • veel eiwit tov totaal stikstof • zelfregulatie, elasticiteit, turgor, weerstand tegen stress and ziekten. • wondherstel na beschadiging • producteigen kleurenverhouding in spectral range luminicentie • samenhang in CC-crystallisatie beelden

Het introduceren van een nieuw kwaliteitsbegrip met experimentele parameters brengt het risico met zich mee van cirkelredeneringen. Immers een onbekend begrip (in dit geval integratie), laat zich moeilijk introduceren via onbekende teeltmaatregelen (zoals biologisch-dynamische preparaten) en meten door experimentele parameters. Experimentele parameters kunnen correleren met bekende parameters (*convergent validity*), zoals de weerstand tegen ziekten en de optimaal gewaardeerde smaak. In dat geval voegen ze geen extra informatie toe en kan gekozen worden voor de minst dure parameter. Maar er kan ook géén correlatie gevonden worden; dit duidt op mogelijke nieuwe aspecten van kwaltiteit. De methodische houvast wordt dan gevonden door zowel te werken aan het theoretisch onderbouwen van het nieuwe begrip, als aan het uitvoeren van experimentele series die het begrip toetsen. Een nieuw begrip (zoals integratie) kan via logisch redeneren afgeleid worden uit bekende plantenfysiologische begrippen (in dit geval groei en differentiatie en bijvoorbeeld zelfregulatie: de *construct validity*). Het nieuwe begrip kan getoetst worden door de gevolgen van experimentele teeltmaatregelen te vergelijken met de verwachting.
De levensprocessen spelen in deze methodologie een cruciale rol; zij vormen de begripsmatige samenhang en het houvast in het kwaliteitsconcept. Als deze experimentele begrippen, uitgevoerde teeltmaatregelen en gemeten parameters zich gedurende meerdere jaren bij verschillende gewassen consistent en praktisch bruikbaar tonen *(predictive validity*), dan kan vertrouwen ontstaan dat 'innerlijke kwaliteit' een zinvol en toetsbaar concept is. Beide wegen komen in dit tweede appelonderzoek aan bod: verdere begripsmatige onderbouwing van het kwaliteitsconcept èn een vervolg experimenteel onderzoek met appels.

Opzet van het tweede experiment met appel

Appels zijn gekozen als testgewas voor het te ontwikkelen van het kwaliteitsbegrip, omdat juist bij appels al zo veel kennis bestaat over innerlijke kwaliteitsaspecten. Bovendien zijn begrippen als groei en differentiatie gemeengoed onder fruittelers. Zij kunnen deze begrippen herkennen en teeltmaatregelen nemen om bij te sturen. De keerzijde van appel als testgewas is dat een appelboom met de verschillende organen (scheut, vrucht, bloemknop, wortel, stam), die in verschillende stadia groeien en differentiëren, de proefopzet en het trekken van conclusies erg complex maken. De uitgebreide gangbare kennis wordt als referentie gebruikt voor de beoordeling van de nieuwe experimentele kwaliteitsparameters en de nieuwe begrippen. Het theoretisch onderzoek naar het kwaliteitsconcept is zo opgezet, dat tevens een aantal praktische vragen uit de betreffende boomgaard beantwoord kunnen worden.

In het eerste appel experiment in dezelfde boomgaard is gekozen voor referentieseries die in kleine stapjes varieerden tussen extremen in groei en differentiatie, te weten rijpingsduur, productieniveau, van licht naar schaduw en veroudering na pluk. In dit tweede appelonderzoek zijn series toegevoegd om het begrip 'integratie' verder te verkennen. Namelijk, één serie met bemestingstrappen waarbij door het bemestingsniveau de verhouding tussen groei en differentiatie verschuift van het ene extreme naar het andere extreme. Hierover heen ligt een serie met en zonder biologisch-dynamische spuitpreparaten. Bij integratie spelen twee aspecten mee, namelijk de verhouding èn de mate van onderlinge samenwerking tussen groei en differentiatie. Het aspect van de verhouding onderzoeken we door de bemestingstrappen en de veronderstelling is dat die biologisch-dynamische preparaten de onderlinge samenwerking tussen groei en differentiatie verhogen. In de serie met bemestingstrappen door handelsmeststoffen is ook nog een variant met compost opgenomen vanuit de veronderstelling dat compost een verschuiving en mogelijk een betere samenwerking tussen groei en differentiatie zal laten zien.

In de boomgaard lagen 4 grote blokken, waarvan 2 wel en 2 niet met Bd-spuitpreparaten zijn behandeld. Binnen elk blok lag een bemestingsserie van 6 veldjes met elk 10 bomen: 1 veldje onbemest, 4 veldjes met verschillende dosering handelsmeststof en 1veldje met half verteerde compost.

De experimentele omstandigheden zijn gecontroleerd op homogeniteit van het proefveld (geringe verschillen in grondsoort), verschil in rijpingssnelheid (niet gevonden), gelijke dracht (goed gevonden) en gestandaardiseerde vruchten voor beoordeling (70-90 mm diameter, gaaf, op middelmatige hoogte in representatieve bomen, geheel tot half in de zon).
Omdat bemesting slechts langzaam doorwerkt in meerjarige gewassen is gekozen om 3 jaar lang de maatregelen uit te voeren en 3 jaar lang het gewas globaal te beoordelen. Alleen in het tweede jaar zijn gewas en de kwaliteit van de appels gedetailleerd gemeten. Van elk veldje werden 80 gestandaardiseerde vruchten voor analyse verdeeld over de verschillende laboratoria.

Conclusies voor deze boomgaard

Effect van bemestingsniveaus

De fruittelers hadden een vraag naar het optimale bemestingsniveau voor een hoge, regelmatige productie en een goede vruchtkwaliteit. Vanuit het kwaliteitsconcept was er de vraag of het bemestingsniveau tot een verschuiving in verhouding tussen groei en differentiatie leidt.
De bemestingstrappen zijn jaarlijks in het voorjaar uitgevoerd met een combinatie van twee handelsmeststoffen. De ene meststof is 'Maltaflor', gemaakt uit restproducten van gangbare suiker- en bierproductie, waaruit nutriënten zeer snel vrij komen. De tweede handelsmeststof is biologische kippenmestkorrel, waaruit nutriënten iets minder snel vrij komen. De bemestingstrappen gelden voor alle nutriënten, maar we drukken ze hier uit in hoeveelheid stikstof omdat stikstof het beperkende mineraal is voor deze boomgaard: 0, 40, 80, 120, 160 kgN / ha.
Na 1 à 2 jaar uitvoeren bleek dat deze vrij grote verschillen in bemesting tot relatief geringe verschillen in de bomen en appels leidde, maar na 2 à 3 jaar werd duidelijk dat 0 en 40 kgN / ha toch duidelijk te weinig was (bomen kwamen in beurtjaar) en dat 160 kgN duidelijk te veel was (slechte vruchtkwaliteit).
Toename in bemestingsniveau liet inderdaad een toename zien van groeikenmerken en een afname van differentiatiekenmerken: meer en langer doorgaande scheutgroei waardoor ook meer schimmelziekten, donkerder groen en groter blad, hogere stikstofgehalten in knop, blad en vrucht, meer en sterkere bloemknopvorming voor het volgende jaar. Bij meer mest waren de appels groter, minder hard en iets minder zuur, met een lager fenolgehalte, meer vruchtrot en minder blos.
Voor het combineren van een regelmatige productie èn appels met een goede innerlijke kwaliteit bleekt het optimale bemestingniveau voor dit perceel rondom 100 kgN / ha. Het gaat om een 12 jarige aanplant van het beurtjaargevoelige ras Elstar op een zwakke onderstam (M9, 2460 bomen / ha) op een grondsoort die stikstof gemakkelijk vasthoudt. Een regelmatige productie van about 40 ton appels / ha onder biologische omstandigheden blijkt hier haalbaar. Naast de vermelde bemesting zijn een tijdige vruchtdunning, water geven bij droogte, voorkomen van concurrentie door onkruid, preventie van schade door nachtvorst, ziekten en plagen de voorwaarden om tot deze productie te komen.

Effect van compost in vergelijking met handelsmeststoffen

De fruittelers hadden een vraag naar de optimale meststof voor een biologisch-dynamische boomgaard. Vanuit het kwaliteitsconcept was er de vraag of compost een maatregel is die tot meer integratie leidt.
Naast deze bemestingstrappen is daarom een variant opgenomen met half verteerde biologisch-dynamische compost (100 kgN / ha) in het voorjaar. We veronderstelden dat compost nutriënten regelmatig over het jaar vrijgeeft en dat dit bij de gebruikte handelmeststoffen vooral vroeg in het jaar gebeurt. Dit laatste past beter bij de veronderstelde behoefte van de boom. Handelsmeststoffen zijn veel gemakkelijker toepasbaar en maken de boomgaard onafhankelijk van een nabije mestproductie.
In dit onderzoek bleek dat het toepassen van compost duidelijke voordelen geeft boven de handelsmeststoffen voor de bodem: meer bodemleven en snellere bladvertering. Snelle bladvertering is van belang om ziekten, zoals appelschurft, niet te laten overwinteren in de boomgaard. Toepassen van de compost liet zien dat boom en vruchteigenschappen op korte termijn (na 1 à 2 jaar toepassing) vergelijkbaar zijn met onbemeste velden en na langere termijn (2 à 3 jaar) vergelijkbaar zijn met de middelmatig bemeste velden met handelsmeststoffen.
Uitgaande van het geven van 100 kgN / ha komt in het geval van compost de voeding iets meer ten goede aan opbouw van de bodemvruchtbaarheid en bij de handelsmeststoffen meer ten goede aan de boom. Van compost zal dus meer kgN / ha gegeven moeten worden om zowel bodem als boom te voeden. Voor de praktijk is de combinatie van compost en handelsmeststoffen ook een goede mogelijkheid.
Na 2 à 3-jarig gebruik van deze mestsoorten vonden we geen verschil meer in de boom of vrucht die verklaard kan worden door het verschil in dynamiek van vrijkomende nutriënten. We hebben ook geen aanwijzingen gevonden voor een betere integratie door compost, behalve de tendens tot betere smaak bij één van de twee smaakpanels.

Effect van biologisch-dynamische spuitpreparaten

De fruittelers hadden de vraag hoe ze de werking van biologisch-dynamische preparaten voor zichzelf en voor de consument duidelijk kunnen ervaren. Vanuit het kwaliteitsconcept was er de vraag of Bd-preparaten een maatregel is die tot meer integratie leidt.
Twee blokken van 33x50 vierkante meter kregen gedurende 2 jaar geen Bd-spuitpreparaten, terwijl in twee andere blokken, in de jaren daarvoor en in het perceel erom heen, het gebruik van preparaten werd voortgezet. Vanwege de onbekende maatregel was het een gok of deze 2 jaar zònder lang genoeg waren (na 80 jaar gebruik

van preparaten), of de afstand tussen wel en niet behandeld ver genoeg was, en of de frequentie van toepassing (about 8 bespuitingen per jaar) effectief was. In de blokken met preparaten werd een significant snellere bladvertering gevonden, die niet verklaard kan worden door andere factoren. Voor de meeste andere verschillen geldt dat ze zowèl door preparaten als door bodemverschillen verklaard worden. Dit komt doordat er slechts 2 onafhankelijke herhalingen in de proefopzet zaten en de meeste parameters slechts geringe verschillen lieten zien. De blokken met biologisch-dynamische preparaten onderscheidden zich in: meer fosfor en kalium in de bodemreserve en in de vrucht, meer calcium in het blad, méér vruchtrot en bewaarschurft na bewaren, tendens tot betere smaak, meer differentiatie en integratie in de kristallisatiebeelden en een andere waarde in luminicentie. Het blijft methodisch lastig om het effect vast te stellen van een maatregel die grote oppervlakten verlangt. Er is dan snel sprake van onvoldoende onafhankelijke herhalingen en van verschillen in bodemomstandigheden. De zekerheid moet gevonden worden door meerdere onderzoeken met vergelijkbare tendens.

Conclusies voor de ontwikkeling van het kwaliteitsconcept

We vonden duidelijke correlaties tussen teeltmaatregelen, kenmerken van de boom en kenmerken van de vruchtkwaliteit. Dit maakt het mogelijk dat de fruitteler tijdens het groeiseizoen kan sturen op gewenste appelkwaliteit. Op basis van beide appelonderzoeken is het mogelijk een groot deel van de parameters te groeperen als groei en differentiatieparameters en te toetsen tegen de gangbare kennis in de fruitteelt. Voor de praktische fruitteelt levert dit niet veel nieuws. De waarde van het onderzoek ligt in de werkwijze om een kwaliteitsconcept te ontwikkelen om deze vervolgens toe te passen op gewassen waarbij weinig bekend is over de relatie tussen teeltmaatregelen, gewaskenmerken en productkwaliteitskenmerken. Ook biedt het een methode voor de validatie van de experimentele parameters.

Het karakteriseren van parameters

In tabel 1b staan teeltmaatregelen, fysiologische processen en productkenmerken genoemd op basis van literatuur en ervaringen van telers. In de beide appelonderzoeken is dit ook inderdaad gevonden voor de hierna genoemde parameters.

Groei

Parameters voor groei van de boom zijn: dracht (mits gelijke scheutgroei en dracht vorig jaar), scheutgroei (combinatie van aantal scheuten, scheutlengte, afsluiting van de scheutgroei en mits gelijke dracht), bladgrootte of -kleur (mits gelijke scheutgroei), stikstofgehalte in de knop, stikstof- en magnesiumgehalte in blad en aantasting van schurft. Parameters voor groei van de vrucht zijn: vruchtgrootte of –gewicht (mits gelijke dracht), hardheid (bij gelijke dracht en scheutgroei), zuurgehalte, gehalten van stikstof, vrije aminozuren en eiwit, fris zure en knapperige smaak, groeiscore in kristallisatiebeelden, hoeveelheid biofotonen direct na excitatie, gevoeligheid voor vruchtrot.

Differentiatie

Parameters voor differentiatie van de boom zijn: herfstkleuren en bloemknopvorming (mits gelijke dracht).
Parameters voor differentiatie van de vrucht zijn: kleur van blos, gele grondkleur, vorm van de vrucht, glans, omzetting van zetmeel, differentiatiescore in kristallisatiebeelden, hyperbolische afname van fotonen (Meluna, Kwalis).

Groei èn differentiatie

Voor de meeste plantenprocessen zijn zowel groei als differentiatie van belang. Daarom kunnen veel parameters zowel groei- als differentieparameters zijn, afhankelijk van welke factoren de beperkende factor vormen. Bijvoorbeeld, als bemesting de beperkende factor is voor bloemknopaanleg, dan toont deze parameter zich in een bemestingserie als groeiparameter. Als licht de beperkende factor is, dan toont bloemknopvorming zich in een lichtserie als differentiatieparameter.
Een tweede voorbeeld van parameters die zowel groei en differentiatie laten zien is het gehalte secundaire plantenstoffen, zoals fenolen, vitaminen, aroma en rode kleurstoffen. Bij de vorming van secundaire metabolieten is het vormen van de grondstof (assimilaten) een groeiproces en het omzetten naar de secundaire metabolieten een differentiatieproces. Afhankelijk van het tijdstip van meten en waar de beperkende factoren liggen, wordt een correlatie gevonden met groei of met differentiatie.

Integratie

Er zijn parameters met potentie om wat over de mate van integratie te zeggen. Deze zijn: weerstand tegen ziekten en plagen, aroma, zoetheid, overall smaak, fenolen, verhouding eiwit en vrije aminozuren, integratiescore in kristallisatiebeelden, producteigen kleurenverhouding in spectral range luminicentie (Kwalis). De eerste drie zijn algemeen aanvaarde meetmethoden, de laatste drie zijn recent voor wortel en tarwegevalideerde meetmethoden. De gevonden resultaten zijn echter nog niet eenduidig te interpreteren tot een kwaliteitsoordeel. Hiervoor zijn een kwaliteitsconcept nodig waarbinnen deze meetmethoden hun betekenis hebben en nog meer referentieseries, zoals in de beide onderzoeken met appel.

De koperchloride kristallisaties en de spectral range luminicentie passen goed in het kwaliteitsconcept omdat deze beide technieken beoordeeld kunnen worden op alle drie aspecten, groei, differentiatie en integratie. In dit onderzoek met vooral een geslaagde groeiserie is voor beide technieken inderdaad een correlatie gevonden voor het groei-aspect met vele algemeen aanvaarde groeiparameters. In dit onderzoek hebben we een te grote variatie gevonden bij de electrochemische metingen om verschillen tussen de behandelingen te vinden.

Aanbevelingen voor verder onderzoek

Volgende stappen in de validering van het kwaliteitsconcept zijn:

- Het plantenfysiologisch onderbouwen van het begrip integratie met bijbehorende teeltmaatregelen. Pas dan kunnen experimenten rondom integratie opgezet worden voor appel en andere gewassen.
- Uitvoeren van experimentele series voor andere producten dan appel en wortel. Eisen die aan het experiment gesteld worden zijn:
  - eenvoudig gewas met weinig verschillende organen.
  - variatie in teeltmaatregelen waardoor variatie in één factor in kleine stappen van tè weinig tot tè veel; andere factoren blijven constant.
  - aanwezigheid van ziekten en plagen na de jeugdfase, omdat de mate van weerstand een belangrijk integratie kenmerk is.
- Het plaatsen van het innerlijke kwaliteitsconcept tussen andere kwaliteitsconcepten.
- Het leggen van de relatie tussen dit concept en menselijke of dierlijke gezondheid vanuit een holistische visie op gezondheid, en vervolgens gezondheidsonderzoek.

1.3 Deutsche Zusammenfassung und Schlußfolgerung

Parametern für Apfelqualität und die weitere Entwicklung des Begriffs der 'Inneren Qualität' 2001-2003.

Joke Bloksma, Martin Northolt, Machteld Huber, Pieterjans Jansonius, Marleen Zanen, Louis Bolk Instituut 2004.

....
Dann hat er die Teile in seiner Hand,
Fehlt, leider nur das geistige Band.
Goethe in Faust

Anlass

Gesellschaftliches Interesse für Aspekte der inneren Qualität

Viele Produkte aus ökologischem Anbau werden von Spitzenköchen ihres guten Geschmacks wegen gerühmt. Bauern wissen, dass für einen guten Geschmack eine nicht allzu hohe Produktion, eine mäßige Düngung, sorgfältige Reifung sowie Frische eine wichtige Rolle spielen. Vor allem in der konventionellen Landwirtschaft, neuerdings jedoch auch in zunehmendem Maße in der ökologischen Landwirtschaft stehen die Kosten dermaßen unter Druck, dass Konzessionen hinsichtlich der inneren Qualität gemacht werden. Auch in der ökologischen Landwirtschaft bemüht man sich um höhere Erträge, werden größere Mengen Dünger eingesetzt, wird früher geerntet und macht man Gebrauch von Handelsketten, bei denen längere Transport- und Lagerzeiten anfallen; dies alles um die Kosten zu drücken. Bauern, Gärtner und Händler sind auf der Suche nach Anhaltspunkten dafür, wie weit sie mit dieser Kostensenkung gehen können, ohne die gute innere Qualität der Produkte zu beeinträchtigen.
Bei der Veredlung der Kulturpflanzen sind Fragen über die Vor- und Nachteile genetischer Modifikation aufgekommen. Stimmt es, dass genetisch veränderte Pflanzen weniger „Zusammenhang“ aufweisen, und wenn ja, wirkt sich dies ungünstig auf die Gesundheit aus? Ist es für die Gesundheit von Vorteil, Sorten mit besonders hohen Gehalten an Vitaminen oder Phenolen zu züchten? Welche Bedeutung haben Zusammenhang, Struktur und Reife oder die Produkttypizität für den Geschmack und für die Gesundheit des Verbrauchers? Dies ist die Art von Frage, auf die eine Antwort gesucht wird.
Die Beurteilung der Qualität von Nahrungsmitteln sollte sich nicht auf Aussehen, ein paar einzelne Inhaltsstoffe und unerwünschte verunreinigende Stoffe beschränken. Darum ist für Ernährungsprodukte ein neuer Qualitätsbegriff vonnöten. Dies ist sowohl für die ökologisch als auch für die konventionell orientierten Handelsketten eine äußerst aktuelle Frage, wenn sie ihre Verbraucher gut bedienen wollen.

Zusammenarbeit innerhalb der internationalen Vereinigung „organic Food, Quality and Health“

Die internationale Forschungsvereinigung “Organic Food, Quality and Health” (FQH) wurde gegründet, um die Forschung über die Gesundheitseffekte hochwertiger ökologischer Nahrungsmittel zu fördern. Dazu ist ein kohärenter Qualitätsbegriff mit nachvollziehbaren Parametern und Forschungsmethoden zur Messung von Gesundheitseffekten erforderlich. Diese langfristige Zielsetzung bildet den Rahmen der hier vorgelegten Untersuchung.
Der erste Schritt besteht in der Entwicklung von Qualitätsbegriffen und Parametern zur Messung einzelner Qualitätsaspekte. Dazu wurde in der ersten Untersuchung an Äpfeln der vorläufige Begriff der „vitalen Qualität“ eingeführt. In dieser zweiten Apfeluntersuchung wurde dieser Begriff zur „inneren Qualität“ weiterentwickelt. Inzwischen wird auch eine ähnlich angelegte Untersuchung in Bezug auf Möhren durchgeführt. Erst wenn Qualität umschrieben und messbar ist, ist der nächste Schritt möglich, nämlich die Prüfung, ob Produkte mit einer hohen „inneren Qualität“ in der Tat für (bestimmte Gruppen von) Menschen gesünder sind.

Partner und Geldgeber

Partner in dieser zweiten Untersuchung an Äpfeln waren: Orchard ter Linde in Oostkapelle (NL), Kwalis Qualitätsforschung Fulda (D), Meluna Biofotonen-onderzoek in Geldermalsen (NL), Elektro-chemisches Qualitätslabor, Weidenbach (D), Biodynamic Research Association Dänemark (DK) sowie das Louis Bolk Instituut

in Driebergen (NL). Außerdem haben wir von den Diensten von vielen anderen Gebrauch gemacht.
Das Projekt wurde finanziell ermöglicht von Boomgaard ter Linde (NL), Stichting Triodos Fonds (NL), Rabobank (NL), Software AG Stiftung (D), Zukunftsstiftung Landwirtschaft (D), Meluna (NL), Kwalis Qualitätsforschung (D) und dem internen Projektfonds des Louis Bolk Instituuts (NL).

Begriff der Inneren Qualität

Kohärenter Qualitätsbegriff für lebende Produkte

Es wurden unterschiedliche Kriterien aufgestellt, die ein Qualitätsbegriff erfüllen sollte. So sollte er an die Arbeitsweise eines (ökologischen) Landwirts anknüpfen: Er oder sie unterstützt Lebensprozesse in Pflanze oder Tier. Dabei sind Wachstums- und Differenzierungsprozesse zu unterscheiden, und diese können in unterschiedlichem Verhältnis zueinander stehen und einander wechselseitig beeinflussen (Integration).
Der Qualitätsbegriff sollte auch eine Verbindung zwischen den verschiedenen Gesichtspunkten herstellen, unter denen Verbraucher die Qualität des Produktes im Laden beurteilen, und die Landwirte ihre Gewächse. Dies macht es möglich, dass der Obstbauer während der Kultur lenkend eingreifen kann, um die Qualität des Endproduktes, unter Berücksichtigung der saison- und bodenartbedingten Verschiedenheiten, zu optimieren. Verbraucher haben keine einheitlichen Wünsche; sie wählen ihre Nahrungsmittel je nach individueller Vorliebe, Gesundheit und Gemütszustand. Es besteht ein Markt für unterschiedliche, gute Qualitäten, wie zum Beispiel lang haltbare, frische, knackige Äpfel neben zarten, süßen, aromatischen Äpfeln. Während des Anbaus können bereits derartige Schwerpunkte gelegt werden. Die optimale Qualität ist nicht für jedem gleich. Die schematische Darstellung des Qualitätsbegriffs (Tabelle 1c) enthält daher drei Spalten, in denen Kulturmaßnahmen, Lebensprozesse und die Produkteigenschaften miteinander in Zusammenhang gebracht werden.

Neue Bezeichnungen im Zusammenhang mit dem Qualitätsbegriff seit 2001

Der Begriff der Vitalität, wie er im ersten Apfelprojekt eingeführt wurde, sorgte für einige Verwirrung, obwohl „Vitalität“ in der ersten Apfeluntersuchung eindeutig als Resultat von Wachstumsprozessen definiert war; darum wurde diese Bezeichnung aufgegeben. Aus diesem Grund wurde auch der Oberbegriff „vitale Qualität“ durch „innere Qualität“ ersetzt.
Eine andere Schwierigkeit bestand darin, für die Produkteigenschaften, die sich aus Wachstum, Differenzierung und Integration ergeben, Bezeichnungen zu finden, die sich auf alle Produkte anwenden lassen. „Struktur“ als Resultat von Differenzierung und „Zusammenhang“ als Resultat von Integration decken den Begriff nicht vollständig für alle Produkte. Darum sprechen wir lieber von den Produkteigenschaften des jeweiligen Produktes. Für Äpfel ist zum Beispiel „groß und knackig“ das Resultat relativ starker Wachstumsprozesse, „gelbe Grundfarbe“ das Resultat relativ starker Differentiationsprozesse und „süß und aromatisch“ das Resultat der Integration.

Was ist "Innere Qualität"?

"Innere Qualität" ist eine Erweiterung bestehender Qualitätskriterien hinsichtlich Form und Aussehen, gewünschter und unerwünschter Inhaltsstoffe und der Abwesenheit von Krankheitserregern. Bei der "inneren Qualität" geht es um die Eigenschaften, die zusammen ein arttypisches, ausgereiftes, schmackhaftes und hinreichend haltbares Produkt ergeben. Diese Eigenschaften bilden sich während der Entwicklung des Gewächses in einem ständigen Wechselspiel von Wachstums- und Differenzierungsprozessen, die durch Kulturmaßnahmen des Bauern beeinflusst werden können. Für tierische Produkte sollte in Zukunft ein vergleichbarer Begriff erarbeitet werden.

Methodologie

Diese zweite Untersuchung an Äpfeln ist ein Teil des LBI-Programms, das, im Rahmen der Arbeit innerhalb der FQH-Vereinigung, die Entwicklung und Prüfung eines neuen Qualitätsbegriffs zum Ziel hat. In der ersten Apfeluntersuchung lag der Schwerpunkt auf dem Konzept des Qualitätsbegriffs, auf Wachstums- und Differenzierungsprozessen sowie der Art und Weise diese zu messen. In diesem zweiten Apfelprojekt wurde das Vorgehen zur Validierung dieses Begriffs umrissen und ein Teil der Arbeiten dazu ausgeführt. Bei Anbauern und Untersuchern anderer Kulturen wurde untersucht, ob der Begriff und die beiden Lebensprozesse und ihre Integration für sie erkennbar sind (*Inhaltsvalidität*). Dies war für die Begriffe Wachstum und Differenzierung der Fall. Eine Reihe von Beispielen wurden in der Broschüre “Life processes in crops“ (Bloksma and Huber, 2002) veröffentlicht. Die Begriffe „Integration“ und „Vitalität“ erwiesen sich als problematisch und wurden weiter ausgearbeitet. Neu ist, dass wir die Wachstums- und Differenzierungsprozesse nach Organen unterscheiden (Frucht, Blume, Zweig) und die Entwicklung zum Jahreslauf in Beziehung setzen. Auf die Erwähnung von

Tabelle 1c: Der verbesserte Begriff der "Inneren Qualität" bei Äpfeln auf der Grundlage dieser Untersuchung, der Literatur und Erfahrungen von Obstbauern (? = noch unsicher).

Innere Qualität bei Äpfeln		
KULTURMAßNAHMEN zum Korrigieren des Produktes während der Wachstumsperiode *im Gespräch mit dem Obstbauern*	**PROZESSE** in den Bäumen *im Gespräch mit dem Obstbauern*	**EIGENSCHAFTEN** der Bäume oder des Endproduktes *im Gespräch mit Obstbauer, Verbraucher und Händler*
1. Wachstum		
+ keine Begrenzung durch Nährstoff- oder Wasser-mangel durch optimale Versorgung + Fruchtausdünnung + Wachstumsfördernder Schnitt. + Raum (weiter Pflanzabstand) – Wurzelschnitt, Einsägen des Stammes – kontrollierter Trockenstress – Wachstumshemmender Schnitt.	• Photosynthese: primäre Metabolite (C-Wachstum) • Aufnahme von Stickstoff und anderen Nährstoffen (N-Wachstum) • Füllen der Reserveorgane mit Stärke, Eiweiß usw. • Massebildung • Erhaltung (Grundstoffwechsel)	• grüne, vegetative Masse, Blattgröße, Triebwachstum, Fruchtgröße, Ertrag • Säure, Stärke • Aminosäuren, Eiweiß • Festigkeit, Saftigkeit, Knackigkeit • metabolische Energie • unterschiedliche Schimmelkrankheiten und saugende Insekten (Blattläuse) • viele Biophotonen am Anfang • Expansion, Gliederung und gefullt sein in den CC-Kristallisations Bildern
2. Differenzierung		
+ heller und warmer Standort + Begrenzung des Wachstums + junge Zweige ausbiegen + Hormon Ethylen + Bienenkästen für zusätzliche Bestäubung	• Verfeinerung, Ordnung • Reifung: Stärke -> Zucker; Säure -> Aroma • Sekundärer Metabolismus • Anlage von Pollen, Samen und Blütenknospen.	• differenzierte, feine Formen (Blattzähne, Kork) • Ordnung • Kalzium, kräftige Zellwände • Ethylen (= Reifungshormon) • Reife Farben (gelber Fruchtgrund, Herbstfarben im Blatt) • beißende Insekten (Blütenstecher usw.) und echter Mehltau. • hyperbolische Kurve der Biophotonen • Struktur in den CC-Kristallisations Bildern
1+2 Integration		
+ Sorge für optimales Verhältnis zwischen Wachstum und Differenzierung in jeder Entwicklungsphase + Nährstoffe in richtigem Verhältnis, die gleichmäßig frei werden (Kompost) + passende Sorten + krankheitshemmender Boden (durch Kompost?) + Verschiedenheit? + menschliche Zuwendung? + harmonische Landschaft? + biologisch-dynamische Spritzpräparate?	• Wechselwirkung zwischen Wachstum und Differenzierung in einem Verhältnis, das der Art und der Entwicklungsphase entspricht • Bildung sekundärer Metabolite aus primären Metaboliten • Selbstregulation	• art- und entwicklungsphasen-typisches Verhältnis zwischen Wachstums- und Differenzierungs-merkmalen • schmackhafte und glänzende rote Früchte = Aroma + Glanz + Rot + Fest + Saft + Süß • viele, fruchtbare generative Organe (Samen, Blütenknospen) • Phenole, Vitamin C, Tannin, Wachs, Harze • höhe Verhältnis des Eiweiß- und gesamten Stickstoffgehaltes • Selbstregulation, Elastizität, Widerstand gegen Stress und Krankheiten • Wundheilung nach Beschädigung • arttypische Spektralverteilung der Lumineszenz • Zusammenhang in den CC-Kristallisations Bildern

Pflanzenhormonen bei Wachstumsprozessen wurde verzichtet.
Der Qualitätsbegriff wurde mit einer Reihe von Hypothesen und Ergebnissen aus der Literatur verglichen (*Konsistenz des theoretischen Konstrukts*). Der Begriff lässt sich zum Beispiel gut mit der Growth-Differentiation-Balance-Hypothese aus der pflanzenökologischen Forschung über den Widerstand gegen Krankheiten und Schädlinge verknüpfen. Für den Begriff der Integration muss die Literaturuntersuchung noch weiter fortgesetzt werden. Die Einführung eines neuen Qualitätsbegriffs mit experimentellen Parametern bringt die Gefahr von Zirkelschlüssen mit sich. Ein unbekannter Begriff (in diesem Fall Integration) lässt sich schließlich schlecht mit Hilfe unbekannter Kulturmaßnahmen (wie zum Beispiel biologisch-dynamische Präparate) einführen und anhand von experimentellen Parametern messen.
Experimentelle Parameter können mit bekannten Parametern korrelieren (*Konvergenzvalidität*), wie zum Beispiel der Widerstand gegen Krankheiten und der als optimal bewertete Geschmack. In diesem Fall fügen sie keine neuen Informationen hinzu und kann der kostengünstigste Parameter verwendet werden. Es ist jedoch auch möglich, dass sich keine Korrelation feststellen lässt; dies kann ein Hinweis auf neue Qualitätsaspekte sein. Ein methodischer Bezugspunkt kann dann gewonnen werden, indem man sowohl an der theoretischen Untermauerung des neuen Begriffs arbeitet als auch an der Durchführung von Versuchsserien, mit denen dieser Begriff getestet wird. Ein neuer Begriff (wie zum Beispiel Integration) kann durch logische Folgerungen aus bekannten pflanzenphysiologischen Begriffen abgeleitet werden (in diesem Fall Wachstum und Differenzierung und zum Beispiel Selbstregulation: die *Konstruktvalidität*). Der neue Begriff lässt sich prüfen, indem man die Folgen experimenteller Kulturmaßnahmen mit den erwarteten Werten vergleicht.
Die Lebensprozesse spielen in dieser Methodologie eine entscheidende Rolle; sie stellen den begriffsmäßigen Zusammenhang her und bilden den Bezugspunkt des Qualitätsbegriffs. Wenn diese experimentellen Begriffe, die durchgeführten Kulturmaßnahmen und die gemessenen Parameter sich mehrere Jahre hindurch bei unterschiedlichen Gewächsen als konsistent und praktisch brauchbar erweisen *(Vorhersagevalidität*), kann sich daraus das Vertrauen ergeben, dass „innere Qualität“ ein sinnvoller und nachvollziehbarer Begriff ist. Beide Wege werden in dieser zweiten Untersuchung an Äpfeln beschritten: eine weitere begriffsmäßige Untermauerung des Qualitätsbegriffs ebenso, wie die Fortsetzung der Versuche mit Äpfeln.

Anordnung des zweiten Versuchs mit Äpfeln

Äpfel wurden als Versuchskultur zur Entwicklung des Qualitätsbegriffs gewählt, weil gerade bei Äpfeln bereits weitreichende Erkenntnisse über innere Qualitätsaspekte vorliegen. Außerdem gehören Begriffe wie Wachstum und Differenzierung unter Obstbauern zum Gemeingut. Sie haben eine anschauliche Vorstellung von diesen Begriffen und sind in der Lage, durch Kulturmaßnahmen lenkend einzugreifen. Der Nachteil von Äpfeln als Versuchskultur ist, dass beim Apfelbaum mit seinen verschiedenen Organen (Zweig, Frucht, Blütenknospe, Wurzel, Stamm), die in verschiedenen Stadien wachsen und sich differenzieren, die Versuchsanordnung und das Ziehen von Schlussfolgerungen eine sehr komplexe Angelegenheit ist. Die umfassenden Kenntnisse aus dem herkömmlichen Obstbau werden bei der Beurteilung der neuen, experimentellen Qualitätsparameter und der neuen Begriffe als Bezugsrahmen gebraucht. Die theoretische Untersuchung des Qualitätsbegriffs ist so angelegt, dass dabei gleichzeitig eine Reihe praktischer Fragen aus dem betreffenden Obstgarten beantwortet werden können.

Bei der ersten Apfeluntersuchung im selben Obstgarten haben wir uns für Vergleichsreihen entschieden, die in kleinen Schritten zwischen Extremwerten in Wachstum und Differenzierung variierten, und zwar in Bezug auf Zeitpunkt der Reife, Ertragshöhe, Sonnenlicht und Alterung nach dem Pflücken. In dieser zweiten Untersuchung wurden Serien hinzugefügt, die den Begriff der Integration weiter verdeutlichen sollen. Eine dieser Serien besteht aus unterschiedlichen Düngungsstufen, wobei sich durch die Höhe der Düngung das Verhältnis zwischen Wachstum und Differenzierung von einem zum andern Extrem verschiebt. Diese wurde mit einer Serie mit und ohne biologisch-dynamische Spritzpräparate (=BD-Spritzpräparate) kombiniert. Bei der Integration spielen zwei Gesichtspunkte eine Rolle, und zwar einerseits das Verhältnis und andererseits das Ausmaß der Wechselwirkung zwischen Wachstum und Differenzierung. Das Verhältnis untersuchen wir anhand der Düngungsstufen, und es besteht die Vermutung, dass die Präparate die Wechselwirkung zwischen Wachstum und Differenzierung erhöhen. In die Serie der Düngungsstufen mit Handelsdüngern wurde auch eine Variante mit Kompost aufgenommen, in der Erwartung, dass Kompost eine Verschiebung und möglicherweise eine bessere Wechselwirkung zwischen Wachstum und Differenzierung zu sehen geben würde.

Es gab vier Wiederholungsblöcke: zwei mit biologisch-dynamischen Präparaten behandelt, die anderen beiden nicht. In den vier Wiederholungen wurden sechs Düngungsvarianten auf Feldern von jeweils zehn Bäumen hintereinander ausgeführt: ein Feld ungedüngt, vier Felder mit verschieden hoher Handelsdüngung und ein Feld mit Kompost.

Die folgenden experimentellen Gegebenheiten wurden kontrolliert: Homogenität des Versuchsfeldes (geringe Unterschiede in der Bodenart), Unterschiede im Zeitpunkt der Reife (nicht festgestellt), gleicher Fruchtbehang (gut befunden). Zur Beurteilung wurden standardisierte Früchte genommen (70-90 mm Durchschnitt, unbeschädigt, aus mittlerer Höhe von repräsentativen Bäumen, halb bis ganz in der Sonne).

Da Düngung sich in mehrjährigen Kulturen nur allmählich auswirkt, haben wir uns dazu entschlossen, die Maßnahmen 3 Jahre lang durchzuführen und während dieses Zeitraums die Bäume global zu beurteilen. Nur im zweiten Jahr wurden die Bäume und die Qualität der Äpfel im Einzelnen gemessen. Von jedem Feld wurden 80 standardisierte Früchte zur Analyse über die einzelnen Labors verteilt.

Folgerung für diesen Obstgarten

Effekt der Düngungsstufen

Die Obstbauern hatten gefragt, welche Düngungsstufe für hohe, gleichmäßige Erträge und eine gute Qualität des Obstes optimal sei. Im Rahmen der Untersuchung des Qualitätsbegriffs wurde die Frage gestellt, ob die Höhe der Düngung zu einer Verschiebung im Verhältnis zwischen Wachstum und Differenzierung führen würde.
Die Düngung wurde jeweils im Frühjahr mit einer Kombination zweier Handelsdünger durchgeführt. Einer dieser Dünger ist „Maltaflor“, der aus Nebenprodukten der konventionellen Zucker- und Bierproduktion hergestellt wird und Nährstoffe sehr schnell frei werden lässt. Der andere Handelsdünger ist granulierter biologischer Hühnermist, aus dem Nährstoffe etwas weniger schnell frei werden. Die Düngungsstufen beziehen sich auf alle Nährstoffe; wir drücken sie hier jedoch in der Stickstoffmenge aus, weil Stickstoff in diesem Obstgarten das Mineral ist, das den begrenzenden Faktor bildet: 0, 40, 80, 120, 160 kg N / ha.
Nachdem wir dies 1 bis 2 Jahre durchgeführt hatten, zeigte sich, dass diese ziemlich großen Unterschiede in der Düngung relativ geringe Unterschiede in den Bäumen und Äpfeln zur Folge hatten; doch nach 2 bis 3 Jahren wurde deutlich, dass 0 und 40 kg N / ha eindeutig zu wenig war (die Bäume legten ein Ausfalljahr ein), während 160 kg N eindeutig zu viel war (schlechte Fruchtqualität).
Die Zunahme der Düngermenge äußerte sich in der Tat in einer Zunahme der Wachstumsmerkmale und einer Abnahme der Differenzierungsmerkmale: stärkeres und länger fortgesetztes Triebwachstum und dadurch auch mehr Schimmelkrankheiten, dunklere und größere Blätter, höherer Stickstoffgehalt in Knospe, Blatt und Frucht, Bildung einer größeren Anzahl und stärkerer Blütenknospen für das nächste Jahr. Mit mehr Dünger waren die Äpfel größer, weniger hart und etwas weniger sauer und wiesen sie einen niedrigeren Phenolgehalt, mehr Fruchtfäule und weniger Rotbackigkeit auf.
Etwa 100 kg N / ha erwies sich als optimale Düngermenge für diese Parzelle, wenn man eine regelmäßige Produktion mit Äpfeln einer guten inneren Qualität kombinieren möchte. Es handelt sich hier um einen 12 Jahre alten Bestand der zur Alternanz neigenden Sorte Elstar auf einer schwachen Unterlage (M9, 2460 Bäume / ha) auf einer Bodenart, die leicht Stickstoff festhält. Eine regelmäßige Produktion von etwa 40 Tonnen Äpfel / ha scheint bei ökologischer Bewirtschaftung in diesem Fall erreichbar. Außer der erwähnten Düngung sind eine zeitige Fruchtausdünnung, Bewässerung bei Trockenheit, Vermeiden von Konkurrenz durch Unkraut und die Verhütung von Schäden durch Nachtfrost, Krankheiten und Schädlinge Voraussetzungen, die erfüllt sein müssen um diese Produktion zu erreichen.

Effekt von Kompost im Vergleich zu Handelsdüngern

Die Obstbauern hatten gefragt, welches das beste Düngemittel für einen biologisch-dynamischen Obstgarten sei. Im Rahmen der Untersuchung des Qualitätsbegriffs wurde die Frage gestellt, ob die Gabe von Kompost eine Maßnahme ist, die eine höhere Integration bewirkt.
Außer den genannten Düngungsstufen wurde darum eine Variante in den Versuch aufgenommen, bei der im Frühjahr halb verrotteter Kompost (100 kg N / ha) gegeben wurde. Wir gingen davon aus, dass Nährstoffe aus dem Kompost in gleichmäßiger Verteilung über das Jahr frei werden, während dies bei den verwendeten Handelsdüngern in erster Linie früh im Jahr geschieht. Letzteres entspricht besser dem mutmaßlichen Bedürfnis des Baumes. Handelsdünger sind viel gebrauchsfreundlicher und haben den Vorteil, dass der Obstgarten nicht auf eine nahe gelegene Mistbezugsquelle angewiesen ist.

In dieser Untersuchung zeigte sich, dass die Verwendung von Kompost gegenüber den Handelsdüngern in Bezug auf den Boden klare Vorteile bietet: ein regeres Bodenleben und eine schnellere Laubzersetzung. Eine schnelle Laubzersetzung trägt in bedeutendem Maße dazu bei, dass Krankheiten, wie zum Beispiel Apfelschorf, nicht im Obstgarten überwintern können. Die Verwendung von Kompost zeigte, dass Baum und Fruchteigenschaften zunächst (nach 1- bis 2-jähriger Verwendung) mit ungedüngten Feldern, längerfristig (2 bis 3 Jahre) jedoch mit den mittelmäßig mit Handelsdüngern gedüngten Feldern zu vergleichen sind. Wenn von einer Gabe von 100 kg N / ha ausgegangen wird, kommen die Nährstoffe im Fall von Kompost in etwas höherem Maße dem Aufbau der Bodenfruchtbarkeit zugute, während sie bei Handelsdüngern in höherem Ausmaß unmittelbar dem Baum zugute kommen. In der Form von Kompost muss daher mehr N / ha gegeben werden, wenn sowohl der Boden als auch der Baum genährt werden soll. Für die Praxis ist eine Kombination von Kompost und Handelsdüngern ebenfalls eine gute Möglichkeit.
Nach 2- bis 3-jähriger Verwendung dieser Arten Dünger fanden wir im Baum oder in der Frucht keinen Unterschied mehr, der sich aus dem Unterschied in der Dynamik der frei werdenden Nährstoffe erklären ließe. Wir fanden auch keine Hinweise auf eine bessere Integration durch Kompost, außer der Tendenz zu einem besserem Geschmack bei einem der beiden Geschmacksprüferteams.

Effekt der biologisch-dynamischen Spritzpräparate

Die Obstbauern hatten gefragt, wie sie selbst und die Verbraucher die Wirkung der biologisch-dynamischen Präparate deutlich erfahren könnten. Die Frage im Rahmen der Untersuchung des Qualitätsbegriffs lautete, ob die Anwendung von BD-Präparaten eine Maßnahme ist, die eine höhere Integration zur Folge hat. Zwei Blöcke von 33 x 50 Quadratmetern erhielten zwei Jahre lang keine BD-Spritzpräparate, während in zwei anderen Blöcken, in den vorhergehenden Jahren sowie in der umliegenden Parzelle der Gebrauch von Präparaten fortgesetzt wurde. Wegen der Unbekanntheit der Maßnahme war es nicht abzuschätzen, ob diese Periode von zwei Jahren ohne (nach 80 Jahren mit) Präparaten lang genug, der Abstand zwischen behandelten und unbehandelten Feldern groß genug und die Häufigkeit der Behandlung (etwa 8 Bespritzungen pro Jahr) effektiv sein würde. In den Blöcken mit Präparaten wurde eine signifikant schnellere Laubzersetzung festgestellt, die durch andere Faktoren nicht zu erklären ist. Die meisten anderen Unterschiede lassen sich sowohl durch die Präparate als auch durch Bodenunterschiede erklären. Dies kommt daher, dass der Versuchsplan nur zwei unabhängige Wiederholungen enthielt und die meisten Parameter nur geringe Unterschiede zu sehen gaben. Die Blöcke mit biologisch-dynamischen Präparaten zeichneten sich durch Folgendes aus: mehr Phosphor und Kalium in der Bodenreserve und in der Frucht, mehr Kalzium im Blatt, mehr Fruchtfäule und Lagerschorf nach Lagerung, Tendenz zu besserem Geschmack, mehr Differenzierung und Integration in den Kristallisationsbildern und ein abweichender Lumineszenzwert. Es bleibt methodisch schwierig, den Effekt einer Maßnahme festzustellen, die große Oberflächen erfordert. Eine ungenügende Zahl unabhängiger Wiederholungen und Unterschiede in den Gegebenheiten des Bodens machen sich dann schnell bemerkbar. Sichere Aussagen können nur aus mehreren Untersuchungen mit vergleichbarer Tendenz abgeleitet werden.

Folgerung hinsichtlich der Entwicklung des Qualitätsbegriffs

Wir fanden deutliche Korrelationen zwischen Kulturmaßnahmen, Merkmalen des Baumes und Merkmalen der Fruchtqualität. Dies macht es möglich, dass der Obstbauer während der Wachstumsperiode auf die gewünschte Apfelqualität hinlenken kann. Auf der Grundlage der beiden Untersuchungen an Äpfeln ist es möglich, einen Großteil der Parameter als Wachstums- und Differenzierungsparameter zu gruppieren und diese an den herkömmlichen Erkenntnissen im Obstbau zu prüfen. Für den praktischen Obstbau ergibt sich daraus nicht viel Neues. Der Wert dieser Untersuchung liegt in der Vorgehensweise bei der Entwicklung eines Qualitätsbegriffs, die danach bei Kulturen angewendet werden kann, bei denen über den Zusammenhang zwischen Kulturmaßnahmen, Merkmalen des Gewächses und Merkmalen der Produktqualität wenig bekannt ist. Auch bietet diese Untersuchung eine Methode zur Validierung der experimentellen Parameter.

Die Charakterisierung von Parametern

In Tabelle 1c werden Kulturmaßnahmen, physiologische Prozesse und Produktmerkmale wiedergegeben, die aus der Literatur und aus Erfahrungen von Obstbauern stammen. In den beiden Apfeluntersuchungen ließen sich diese in der Tat für die unten genannten Parameter bestätigen.

Wachstum

Parameter für das Wachstum des Baumes sind: Fruchtbehang (vorausgesetzt, dass Triebwachstum und Behang im vorhergehenden Jahr gleich waren), Triebwachstum (Kombination von Zahl der Triebe, Trieblänge, Abschluss des Triebwachstums; gleicher Behang vorausgesetzt), Blattgröße oder –farbe (gleiches Triebwachstum vorausgesetzt), Stickstoffgehalt der Knospe, Stickstoff- und Magnesiumgehalt des Blattes und Schorfbefall. Parameter für das Wachstum der Frucht sind: Fruchtgröße oder –gewicht (gleicher Behang vorausgesetzt), Festigkeit (bei gleichem Behang und gleichem Triebwachstum), Säuregehalt, Gehalt an Stickstoff, freien Aminosäuren und Eiweiß, frisch säuerlicher Geschmack und Knackigkeit, Wachstumsindikatoren in Kristallisationsbildern, Anzahl der Biophotonen unmittelbar nach der Anregung, Anfälligkeit für Fruchtfäule.

Differenzierung

Parameter für die Differenzierung des Baumes sind: Herbstfarben und Blütenknospenbildung (bei gleichem Behang). Parameter für die Differenzierung der Frucht sind: Farbton der Rotbackigkeit, gelber Grund, Form der Frucht, Glanz, Umsetzung von Stärke, Differenzierungsindikatoren in Kristallisationsbildern, hyperbolische Abklingkurve der Photonen (Meluna, Kwalis).

Wachstum und Differenzierung

Für die meisten Pflanzenprozesse sind sowohl Wachstum als auch Differenzierung von Bedeutung. Darum können viele Parameter sowohl Wachstums- als auch Differenzierungsparameter darstellen, je nachdem, welches die begrenzenden Faktoren sind. Wenn zum Beispiel die Düngung den begrenzenden Faktor für die Anlage von Blütenknospen bildet, erscheint dieser Parameter in einer Düngungsserie als Wachstumsparameter. Wenn Licht der begrenzende Faktor ist, erscheint die Blütenknospenbildung in einer Lichtserie als Differenzierungsparameter.
Ein weiteres Beispiel von Parametern, die sowohl Wachstum als auch Differenzierung wiedergeben, ist der Gehalt an sekundären Pflanzenstoffen, wie zum Beispiel Phenole, Vitamine, Aromen und rote Farbstoffe. Bei der Bildung sekundärer Metabolite ist das Formen des Grundstoffes (Assimilate) ein Wachstumsprozess und die Umwandlung in die sekundären Metabolite ein Differenzierungsprozess. Je nach dem Zeitpunkt der Messung und den begrenzenden Faktoren ist eine Korrelation mit Wachstum oder mit Differenzierung festzustellen.

Integration

Es gibt Parameter, die das Vermögen besitzen, etwas über das Ausmaß der Integration auszusagen. Dies sind der Widerstand gegen Krankheiten und Schädlinge, Aroma, Süßigkeit, der Gesamtgeschmack, Phenole, Verhältnis zwischen Eiweiß und freien Aminosäuren, Integrationsindikatoren in Kristallisationsbildern, produktspezifische Spektralverteilung der Lumineszenz (Kwalis). Die ersten drei stellen allgemein akzeptierte Messmethoden dar; die letzten drei sind kürzlich für Möhren und Weizen validierte Messmethoden. Aus den gewonnenen Ergebnissen lässt sich jedoch noch kein eindeutiges Qualitätsurteil ableiten. Dazu ist ein Qualitätsbegriff erforderlich, innerhalb dessen diese Messmethoden ihre Bedeutung haben, und mehr Vergleichsreihen, wie sie in den beiden Untersuchungen an Äpfeln vorliegen.

Die Kristallisationsbildern und die Spektralverteilung der Lumineszenz lassen sich gut in den Qualitätsbegriff einpassen, da beide Techniken in Bezug auf alle drei Aspekte: Wachstum, Differenzierung und Integration, beurteilt werden können. In dieser Untersuchung, die vor allem eine gelungene Wachstumsserie erbracht hat, konnte für beide Techniken tatsächlich eine Korrelation für den Wachstumsaspekt mit vielen allgemein akzeptierten Wachstumsparametern festgestellt werden. Bei den elektrochemischen Messungen haben wir in dieser Untersuchung eine zu große Variation feststellen müssen, um auf Unterschiede zwischen den Behandlungen schließen zu können.

Empfehlungen für weitere Untersuchungen

Die nächsten Schritte zur Validierung des Qualitätsbegriffs wären:

- Die pflanzenphysiologische Untermauerung des Begriffs Integration mit den dazugehörigen Kulturmaßnahmen. Erst dann können weitere Versuche zum Thema Integration, mit Äpfel und anderen Gewächsen, geplant werden.
- Die Durchführung von Versuchsreihen für andere Produkte als Apfel und Möhre. Die Versuche müssten die folgenden Bedingungen erfüllen:
  - einfaches Gewächs mit wenig verschiedenen Organen,
  - Variation in Kulturmaßnahmen, so dass ein einzelner Faktor in kleinen Abstufungen von zu wenig bis zu viel

variiert werden kann und übrige Faktoren bleiben konstant,
  * Vorhandensein von Krankheiten und Schädlingen, da der Grad des Widerstandes ein wichtiges Integrationsmerkmal ist.
- Die Platzierung des Inneren Qualitätsbegriffes zwischen andere Qualitätsbegriffe.
- Das Herstellen einer Beziehung zwischen diesem Begriff und der Gesundheit von Mensch oder Tier auf der Grundlage einer holistischen Gesundheitskonzeption, und anschließend Gesundheitsforschung.

2 Introduction

2.1 Background

In search of a relevant and coherent quality concept for organic food production: 'Inner Quality Concept'
Consumers expect organic production to produce a healthy product with a good taste. Sometimes this is the case, sometimes not. Organic production does not guarantee good taste and a healthy product. Besides, – there is no complete agreement about what tastes good and which quality is healthy, and how to achieve this in the growing phase of plants. In the conventional vision, product quality is mainly based on external, physical, nutrient and / or sensory properties and is strongly directed by traders and fashion. In wholefood shops, consumers expect properties such as tastiness, ripeness, vitality and coherence, which are not easy to define or measure. In the past, some experimental parameters have been developed for these consumer requirements. The organic production chain demands scientifically validated food quality concepts and parameters.

A part of the International Research Association for Organic Food, Quality and Health
This study is carried out under the research association for Organic Food, Quality and Health. FQH aims to develop a new concept for food quality that dovetails with the principles of organic production, but which is also suitable for innovations in conventional production (see colofon).

In our first apple study (Bloksma, Northolt and Huber, 2001) the concept of 'vital quality' was developed, based on the life processes of growth and differentiation and their integration. In this second apple study we extended the concept to the 'inner quality' concept and researched it for apples during 2001-2003. A similar project on carrots is running in 2003 after a pilot experiment in 2002 (Northolt, Bloksma and Huber, 2003).

The apple and carrot studies are used to develop the quality concept as well as to validate the experimental parameters with product samples from crops grown under controlled conditions. The concept of life processes can also be a basis for quality management in other crops (Bloksma and Huber, 2002). In the meantime, our FQH partners studying experimental parameters worked on validating their individual measurement methods. The field experiments conducted by us provide them with validation data.

Table 2: Overview of the FQH-experiments by Louis Bolk Instituut and the presumed effect of more of each factor on the life processes

crop	harvest	series in	growth	differentiation	integration
apple	2000	bearing (=yield, 5x)	↓↓		
		sunlight (3x)	↑	↑↑	↑
		ripening (5 harvest dates)	↑	↑↑	
		post-harvest ageing (5x)	↓↓		↓
apple	2002 (2001-2003)	nutrients (5x)	↑↑	↓	
		compost / comm. fert. (2x)			↑?
		BD-preparations / not (2x)			↑?
carrot	(pilot 2002) 2003	nutrients (3x)	↑↑	↓	
		sunlight (3x)	↑	↑↑	↑
		ripening (5 harvest dates)	↑	↑↑	

Working sequence in the experiment
First, we used a preliminary quality concept based on commonly accepted physiological and morphological knowledge and described by us in terms of life processes. We also selected appropriate parameters to assess the results of life processes in our chosen crop. In the field experiments we varied management factors influencing these life processes and measured the resulting crop properties. Besides using Golden Standard measures, we also measured experimental parameters such as delayed luminescence and copper chloride crystallisation (Meier-Ploeger and Vogtmann 1988), to see if they correlated with the Golden Standard methods for the same process. Next we elaborated the preliminary quality concept based on the results of the experiments.

Experiment with apple

At Louis Bolk Instituut we combine work on fundamental questions, such as developing a quality concept, with actual questions from farmers. These apple experiments were selected on the basis of questions from organic orchardists on optimum fertilisation and use of biodynamic field preparations in biodynamic apple growing.

Aims of the second apple project

After the first apple project in 2000-2001 comprising an initial outline of a quality concept and an experiment with four management factors (picking date, bearing, sunlight, shelf life) mainly influencing growth and differentiation, we intend to take some new steps in this second apple project.

1. To check the acceptance of the quality concept in international communities of traders, farmers and scientists and to improve the weak points.
2. To make the quality concept for apples more detailed by evaluating growth and differentiation in the different organs of an apple tree: twigs and leaves, roots, fruits and flower buds. To validate the experimental parameters, we try to find a commonly accepted parameter such as a Golden Standard parameter in every process or subprocess.
3. To search for different factors which largely determine the integration of the growth and differentiation processes. Integration involves both the balance and the interaction between growth and differentiation. We chose three management factors: nitrogen level (knowing from literature and experience that this will influence the ratio of growth:differentiation to create more growth and less differentiation), and biodynamic field preparations, and compost versus commercial fertilisers (these last two factors are supposed to promote the interaction of growth and differentiation).
4. To test the relationship between the properties of the growing crop and the properties of the resulting fruits, we also focus on crop and soil parameters.
5. To know for each parameter how to recognise the influence of growth, differentiation and integration. Later we can decide which parameters are easiest to measure and to interpret in the context of this quality concept.
6. To verify whether growth, differentiation and integration are relevant terms for the quality concept, not only in theory, but also established by experimental data. We intend to use the statistical method of non-linear multivariate analysis (NPCA; Gifi, 1990).

Reading this report

This project and also this report have three aims: to develop a quality concept, to develop experimental parameters and to make recommendations on how to grow apples of good quality. After this introduction (Chapter 2), you will find the work on the quality concept (Chapter 3) and the work on the apple experiment (Chapters 4, 5 and 6), each including background, research questions, method and results. In Chapter 7 the two strands are brought together: the apple results are discussed in the context of the Inner Quality Concept. Of course, the work is not finished, and Chapter 8 looks at future prospects and further questions.

We wrote the report for several target groups:

target group	**read chapter:**
People who want a general idea about the development of the Inner Quality Concept with apple as the example	1= summary (complete translations also available in Dutch and German) and see photos on the CD-ROM
People more interested in the Inner Quality Concept	3, 5, 6, 7, 8, 9
People mainly interested in apple growing	4, 6, 10.1
People interested in measuring quality	5, 10.2
People interested in a particular quality parameter	CD-ROM: concerning the particular parameter: method, all results, statistics, graphics, correlations, comments.

2.2 Cooperation

Participants:

- Louis Bolk Instituut at Driebergen (NL), J. Bloksma, M. Northolt, M.A.S. Huber, PJ. Jansonius, M. Zanen, G.J. van der Burgt, P. Doesburg and A.M. de Weerd: co-ordination, quality concept, extension for the apple growers, description of orchard and crop, leaf series, external quality, copper chloride crystallisations, Botrytis fruit rot-resistance test, quality concept, production of the report and CD-ROM.
- Orchard ter Linde, Oostkapelle (NL), P. Korstanje, H. van Elsacker: management practices in the orchard, preparing biodynamic field preparations and compost, experimental applications.
- Kwalis Qualitätsforschung Fulda Gmbh (D), Dr. J. Strube en Dr. P. Stolz: spectral range luminescence, amino acid analysis and quality concept.
- Meluna Bio-photon Research at Geldermalsen (NL), Dr. R. and E. van Wijk: white light luminescence in cooperation with Dr. A. Popp of the Intern. Institute of Biophysics (D) and quality concept.
- Elektro-chemisches Qualität labor, Weidenbach (D), Dipl.Ing.agr. H. Heilmann: electro-chemical measurements and quality concept.
- Biodynamic Research Association Denmark (DK), J.O. Andersen: quality concept and scientific advisory committee.

Further collaboration with:

- Laboratory of Research Station for Fruit Growing PPO at Randwijk (NL): measurements of fruit colour, firmness, Brix, starch, acid and storage of the apples.
- Laboratory for Soil, Crop and Environment, Zeeuws Vlaanderen (NL): analysis of dry matter and minerals.
- Laboratory for soil and crop research (Bllg), Oosterbeek (NL): analysis of manure.
- Tech. Univ. München, Inst. fruit science (D): Prof. Dr. D. Treutter: analysis of phenolic compounds.
- University of applied sciences in Fulda, Fachbereich Haushalt und Ernährung, Labor Sensorik und Lebensmittelverarbeitung Fulda (D), Dr. L. Page: sensory test-1.
- U. von Schoultz: sensory test-2, Järna (SE).
- Gaia, Doorn (NL): soil analysis.
- Soil Foodweb Europe, Hilversum (NL): soil life.
- Team Ecosys, Twello (NL): soil and manure chromas.
- Muvara: D. Nierop, Leiden (NL): statistical consultant.
- A. Ackersmans, Amersfoort (NL): consultant, biodynamic field preparations.
- Forschungsinstitut für biologischen Landbau, Frick (CH), Dr. F. Weibel, E. Kieffer: quality concept.
- Forschungsinstitut für biologischen Landbau, Frick (CH), Dr. G. S. Wyss: scientific advisory committee.
- Dr. J. Fritz, Bonn (D): quality concept.
- Univ. Kassel (D), N. Busscher: quality concept.
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- 'Elketekst', E. Bussler (NL): German language.
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3 Development of 'Vital Quality Concept' into 'Inner Quality Concept'

3.1 Introduction to the quality concept

In the first apple report (Bloksma, Northolt and Huber, 2001) the 'Vital Quality Concept' based on organic principles was presented as a concept for nutritional quality. The concept was based on the life processes of 'growth' and 'differentiation' and their 'integration' (= balance and interaction). The concept had two dimensions: one for growers about processes and one for consumers about product properties, see diagram on page 7 in the first apple report. The two dimensions are connected by the life processes which provide the consistency in the concept.

To recap, the aim of this quality concept was to design a concept for food quality with three intentions:

- First to support the inner nutritional quality for which (organic) agriculture strives: a tasty and healthy product, described in positive terms. So not only in negative terms, as modern standards of food safety emphasise (no residues, no microbes, etc.). Also, to find a basis for the rather vague idea in organic agricultural communities that good food needs to be matured and have some coherence. Coherence is thought to be reduced in genetically modified products, in hybrid crops and in artificially composed food.
- The second aim is to relate quality to the human health concepts used by holistic health workers and dieticians. For them growth, differentiation and integration are meaningful concepts.
- The third aim for a food quality concept is to connect product properties to management measurements by growers. Growers have to be able to recognise the quality at the growing stage and to take appropriate and timely measures when quality threatens to be compromised. We use 'life processes' to describe this connection between the growing crop and the product properties on the shelf. So the life processes are the leitmotiv in the concept. We try to express the life processes in conventional plant physiological terms, as a link to commonly accepted science.

Balancing the main life processes for optimal food quality is not a new idea. We have already encountered this way of thinking in the biodynamic tradition (e.g. Schuphan, 1961; Engquist, 1963; Klett, 1968; Pettersson, 1970; Koepf, Pettersson and Schaumann, 1977; Schaumann, 1982; Heinze, 1983; Fritz, 1990 / 2001; Bisterbosch, 1994; Kunz, 1999; Bauer, 1999) and in scientific plant physiology (e.g. Herms & Matson, 1992; Lerdau et al., 1994; Galston, 1997). The new step we try to add is using these life processes as a framework for a coherent quality concept in which the various individual quality properties can have a meaningful context and be linked to a recommendation to improve the quality anywhere in the production chain. In the long term they can also be linked to human and animal health. Another new facet of this concept is that we are not seeking a single optimum quality. There is some freedom in choosing accents in quality, either more growth-related or more differentiation-related quality. For example, there are customers who like green, firm and juicy apples (accent on growth) and customers who like blushed, sweet and aromatic apples (accent on differentiation).

3.2 Method: quality concept validation process

Not only do the individual new parameters have to be validated as a laboratory technique, a new concept also needs a validation procedure. The steps to validate a new concept are explained in table 3. We put emphasis on this validation procedure because we ran into a number of vicious circles when it came to new properties and new parameters, especially at the level of integration, and so we need an anchor in careful reasoning.

Table 3: Scientific validation process to measure inner quality of food products. The methodological steps are shown in italics. Ö indicates that this step has already been completed (Streiner and Norman, 2001).

1. Development of hypothesis of food quality suitable for organic products and their consumers *defining what is suitable for organic agriculture and its consumers*		
	1. based on life processes (growth, differentiation and integration of both) 2. relating processes (growers) to properties (consumers) 3. related to holistic human health concept used by physicians and dieticians	Ö Ö (Ö)
2. Development of a quality concept *distinguishing domains, items, to find relevant properties and parameters*		
	see table 1 for the Inner Quality concept and table 35 in §7 for the parameters	Ö
3. Consistency of the hypothesis of the 'Inner Quality Concept' *(construct validity)*		
	3.1. Consistent in itself ?	Ö
	3.2. Consistent with current theories ? Yes for growth and differentiation; no for integration	Ö / -
	3.3. Consistent with existing empirical data ? Only a few controlled studies available	Ö / -
4. Predictive validity of the concept		
	4.1. Meaning recognised by workers in the field *(face validity)* also for crops other than apple	Ö
	4.2. Are quality aspects recognised by specialists? *(content validity, all domains and items are included ?)* Yes for growth and differentiation; no for integration	Ö / -
5. Predictive validity of individual parameters depends on parameter		
	5.1. Absence of systematic error; does it measure what it should? *(validity)*	Ö / -
	5.2. Same results from different observers, laboratories, days, etc.? *(reproducibility)*	Ö / -
	5.3. Enough discrimination? (*sensitivity of response to changes in quality*)	Ö / -
	5.4. Parameter consistency: Good correlation between parameters for the same item? *(internal consistency)*	Ö / -
6. Development of a new parameter depends on parameter		
	6.1. Parameter compared with Golden Standard parameter in an experiment with controlled products (c*onvergent validity*) For growth parameters many √	Ö / -
	6.2. Compare to logic (e.g. physiological process) if no Golden Standard parameter available. **Experimental results to confirm validity of hypothesis** *(construct validity)* Only a few integration parameters, because physiology is not worked out	Ö / -

Since 2001 we added the following new steps to the validation process. The concept was discussed over a two-year period in communities of practical workers (*face validation* by farmers, dieticians and consumers) and in communities of scientific experts and literature (*content validation*), such as the international conferences on organic fruit growing (Bloksma, 2001, 2002), the Round Table Conference in May 2003 in Driebergen. This led to some new terms and new positioning of old properties in the new design concept, see §3.3.

At the start of this second study we tried to divide the main processes into several sub-domains to find the relevant properties and measurements on such a detailed level that we could correlate experimental and commonly accepted parameters for the *convergent validity*. This resulted in a very complex scheme with time and organs specified. The added conditions relating to standardisation are found in table 35 in §7. However, the correlations found were no closer when we examined more subprocesses, so we have not included this effort in this report. For integration, where *construct validity* is of major importance, we need further literature review, and work on concepts such as self-regulation and coherence, which has not been completed within this apple project. In the meantime the various partner laboratories have worked on the *predictive validity* of their parameters. Recently, predictive validations of copper chloride crystallisation, spectral range luminescence, protein ratio, but not yet of electro-chemical measures were presented at the symposium 'new approaches in food quality analysis', Berlin 13–14th November 2003 (Bloksma et al., 2004).

3.3 Results: improvements to the quality concept since 2001

Since 2001 we have introduced some improvements. We explain all the new thinking, particularly for those people familiar with the concept from 2001 and who have been working with us on improvements. Other readers may wish to go straight to chapter 4.

1. A more general concept for all products

We were also testing the concept for other crops and we described a more general concept for all products; see the carrot projects (Northolt et al., 2003) and the booklet about life processes for crops in general (Bloksma and Huber, 2002). This makes the concept broad and generally recognised and suitable for use in organic production. Growers do recognise the challenge of influencing growth and differentiation as two interacting life processes in their work. Growers of flower, fruit and seed crops clearly recognise the conflicting demands of quantity (growth) and differentiation (ripening) which particularly concerns quality in their crops. Potato and leaf vegetable growers mainly focus on growth processes and only some of them recognise the benefits of differentiation. For example a lettuce grower explained how to grow ‘mature lettuce’ instead of ‘baby lettuce’.

2. Link to crop management

We added a third dimension (third column), the management measures related to the life processes, which promote the best balance between growth and differentiation to be achieved by growers. This gives the concept practical feasibility for quality management in the production phase. For apple it is elaborated in table 1 in this report.

3. Link to human health

We are working on a fourth approach to link product properties to human health. The first ideas are mentioned in the booklet about life processes. In this context we are also looking for potential research models to use the same levels based on life processes (Bloksma and Huber, 2002). This approach is not described in this report as it is still in the early stages.

4. Time-context

The previous description of the concept or the ‘development phase’ lacked a time dimension. So we introduced the development of the crop in the season as a time axis and worked out the balance between growth and differentiation in each developmental stage based on literature on apple physiology. For example: some growth just after bloom improved fruit firmness, but growth later in the summer would decrease firmness. See figure 4 for the hypothetical life process for apple. This time shift is a complication for the concept based on the relationship between life processes, property and management measures.

5. Organ differentiation

Growth is not equally distributed in the various organs such as roots, shoots, fruits, etc. For example, fruits can grow vigorously in July and compete with shoot and root growth in this period. The apple tree has its priorities for carbohydrate supply in times of shortage. Fruits have a higher priority than shoots, trunk or roots (Friedrich and Fischer, 2000). This means that an overall line for growth and differentiation needs to be split up into several lines for each organ, see figure 4. A shoot can grow in mass with many leaves and mature in a terminal bud and later in coloured leaves. A fruit can grow in size and later mature in colour, shine and taste. Fruits and shoots do this independently in the season. This is a second complication for the concept.

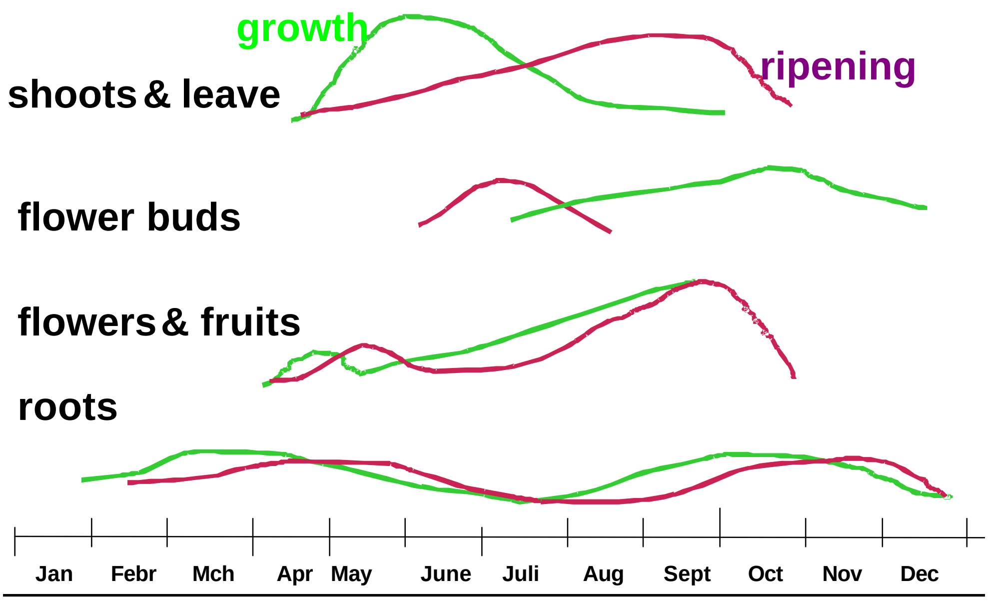


Figure 4: Growth and differentiation in several parts (organs) of the apple tree in the season (adapted from Friedrich and Fischer, 2000; Dierend et al., 1996).

6. We omitted storability and plant hormones

We did not include storability as a property of integration because it can be influenced by a large number of factors: intensive growth (e.g. high nitrate in red beet, Raupp 2001), unripe apple (less maturing) or rot-resistance (very well integrated). We did not consider the growth hormones as the physiology is too complex (Fritz, 1990).

7. Integration probably has two aspects: balance and interaction

There are two aspects to the integration of the life processes of growth and differentiation. The balance aspect of integration is commonly recognised. An understanding of balance is reached by looking at examples of out-of-balance situations. Possible examples include a tall, weak plant in shade which lacks differentiation by light (too little differentiation). A lettuce crop accelerated by fertilisers lacks taste and is susceptible to diseases (too much growth). Emergency flowering in a dry location lacks vigour (too little growth). Aphids suck growing substances (amino acids) and this results in dry, mummified fruits (too little growth).
However the second aspect, the presumed interaction or intermingling of growth and differentiation, is still very much an unknown quantity in mainstream plant physiology. It is recognised as an aim by biodynamic breeders of food crops and users of biodynamic field preparations, who also express this as ‘plant-typicity’. Conventional plant physiologists admit that there is a lack of understanding of the physiological basis for plant resistance and self-regulation. This aspect needs to be further elaborated.

8. Growth-differentiation-balance hypothesis

The ‘growth-differentiation-balance hypothesis’ (= GDBH) in plant defence strategies (Herms and Mattson, 1992; Lerdau et al., 1994) focuses on the expression of the phytochemicals in different environments. In this hypothesis ‘growth’ is used for primary metabolism and ‘differentiation’ for secondary metabolism. Secondary metabolism is the synthesis of phytochemicals for defence against pathogens and biotic stress. The balance between carbon and nitrogen is important, because primary metabolism produces carbohydrates and secondary metabolism uses these carbohydrates, nitrogen and other substances to produce phytochemicals for resistance. In resource-rich environments, resources are allocated to primary growth and diverted away from secondary metabolism. In contrast, when plants are subjected to a stress that limits growth more than it limits photosynthesis, secondary metabolism will increase. For phenols that give an apple leaf its scab resistance, it is proven that with increasing nitrate supply the shoot growth rate accelerates and reduces the synthesis of phenols. On the other hand a minimum nitrogen supply is necessary for phenol synthesis (Rühmann et al., 2002). This is an argument for distinguishing between C-based growth and N-based growth in the concept. This GDB hypothesis is very much in line with the Inner Quality Concept.

9. The dependency of differentiation on previous growth

In the first concept we encountered some difficulties in positioning the properties of differentiation processes. Secondary metabolism or ripening is a clear differentiation process. But the secondary metabolism only can produce phenols, vitamins, and colours when enough primary metabolites are available as primary metabolites from the preceding growth process. Consequently the formation of primary metabolites is a growth process and the formation of secondary metabolites from the primary metabolites is a differentiation process. We need both processes in the right balance to obtain finally a high amount of secondary metabolites. To improve on this we now place the final presence of plant-resistance chemicals (phenols, vitamins, etc.), colours and flavour at the level of integration. For sugar there is a similar complication: sugar from the photosynthesis (in leaves) is a clear growth process and converted sugar from starch in fruits is a differentiation parameter only on condition of enough previous growth.

10. The overall term 'Vital Quality' was confusing and was replaced with 'Inner Quality'

The term 'Vital Quality' was the original choice (emphasising the relationship with life and human health). Traders love the word 'Vital', but it leads to confusion because of the many different ways in which this term is already used. We considered alternatives such as 'Organic Quality' (emphasising the coherence in living organisms and products, but also easily confused with the organic label) or 'Whole Quality' (confused with unrefined 'whole-food', and no good Dutch translation available). We considered 'Ripe Quality' (emphasising the differentiation process rather than the growth process which is the object of modern agriculture, but this term was not relevant for many products, such as salad and milk, and conveyed the suggestion of a risk of over-ripeness). At the moment we are quite content with the term 'Inner Quality' (emphasising the inner properties such as taste and health rather than just the external properties). The term 'inner' does not have as much meaning, but it is not yet charged with as much confusion as the previous terms. It translates easily into German (Innere Qualität) and Dutch (innerlijke kwaliteit).

11. We omitted 'vitality' resulting from growth, as it caused much confusion

The term 'growth' (in German: 'Wachstum' and in Dutch 'groei') for the process is appropriate for all groups, as is 'production of mass' which is more literally the process. However the related property 'vitality' gives rise to too much confusion because for some vitality is the result of growth (powerful green growing mass) and for others it is the result of integration (resistance, self regulation, staying healthy). Cell biologists recognise the term 'cell vitality' for a cell which grows well. Seed growers generally use the term 'seed vitality' for seeds that germinate easily. Ursula Graf uses 'vitality' in the integrated meaning in her picture forming methods. By now we are trying to avoid the terms 'vital' and 'vitality'. Alternative terms for this property might be 'growing' or 'massing' in English; 'üppig', 'wuchskräftig' or 'Masse' in German and 'groeikrachtig' of 'uitdeiende massa' in Dutch. Here we strike another difficulty in that growth also includes 'physiological maintenance' (no mass increase), as seen in the continuous building up (assimilation) and breaking down (dissimilation) of the body. This is not well expressed by 'growing', etc. We stopped searching for a single term for the overall property which would be suitable for all crops and all organs. We settled on 'green and vigorous' for the apple tree and 'big and firm' for apple fruit.

12. We did not consider 'structure' due to differentiation

Refining and ordering the grown mass according to fine forms, leaf serrations, colours, etc. as the formative process to ongoing growth is recognised by all groups. In organic agriculture communities 'differentiation' (in German: Differentiation and in Dutch: differentiatie) is a recognised term. In some scientific plant physiological circles 'differentiation' is only used to describe the formation of new organs or phases in the plant development. For example, the formation of flower buds starts a new phase.

'Structure' was used for the property in the first concept, emphasising the refinement in form. 'Structure' also suggests stiffness and rigidity, which does not reflect the ripening process with its volatile components and colours. 'Order' is a very suitable term in relation to overcoming chaos in life processes. The associated property is 'ordered', 'differentiated' or 'refined'. In German: gereift, gegliedert, verfeinernt and in Dutch: gerijpt, verfijnde vorm, geordend. We stopped searching for a single term for the overall property (properties? character?) to suit all crops and organs. We settled on 'flower bud initiation' for the apple tree, and 'ripe' for the apple fruit.

13. We are considering the introduction of the term 'mature' or 'matured' due to integration

We emphasise that the integration of the two interacting processes, growth and maturing, is not a third process,

but just a third aspect to consider when assessing quality. At present, until integration is further elaborated, we continue to use the term ‘integration’ (German: Integration, Dutch: integratie). We also stopped trying to find a better term for the property of ‘coherence’ (German: Zusammenhang; Dutch: samenhang). ‘Kohärenz’ in German already has another meaning in light physics. Maybe, we will have to split this later into ‘balance’ and ‘interaction’.
For apple trees coherence can be described as ‘moderate resistance to stress and diseases’ and for fruits ‘aromatic and crispy’. The term ‘to mature’ is used literally: to reach a state of full natural development. We like the term ‘mature’ for the integrated aspect. This term is not only used for fruits, but also for the crop as a whole, it includes the vegetative growth, flowering and fruiting. There is a subtle difference from the term ‘to ripen’, which is literally ‘to get ready for harvest’ and is mainly used for fruits. Ripening is the differentiation aspect.

14. Is there reason to distinguish between differentiation and integration?

In German it is not easy to express this distinction between ripening and maturing. The words ‘Reifung’ and ‘Reifequalität’ are used for both differentiation and integration. When Klett (1968) or Fritz (2001) speak about the polarity in life processes of ‘Wachstum und Reife’, they mean growth and differentiation. When Bauer (1999), Kunz (1999) or Kwalis speak about ‘Reifequalität’ they mean the mature product, well differentiated after sufficient growth. The question arose as to whether there are advantages in distinguishing between differentiation and integration as in this quality concept. Because differentiation is so dependent on the results of growth, high differentiation often resembles high integration. The deciding point is whether it is useful to describe situations where too much differentiation exists for maximal integration. We expect to find high differentiation and moderate integration in cases of emergency ripening or in wild plants before they are bred to become cultural plants. It is also possible to find a moderate differentiation and a moderate integration. Another consideration when distinguishing between differentiation and integration is the possibility that the amount of integration of growth and differentiation is independent of the balance between them, but dependent on the interaction. Up to now we have no appropriate experimental data to favour one or the other opinion. So these possible opinions wait for an opportunity to be discriminated more clearly.

All these considerations together led to the newly designed concept of ‘Inner Quality’ as a successor to the concept of ‘Vital Quality’. The new concept is described in table 1a, 1b, 1c in three languages in the summaries.

4 The apple experiment (2001-2003)

4.1 Research questions

In this orchard experiment we have 3 varying factors: nitrogen-level (5 levels), type of fertiliser (2 types) and biodynamic field preparations (yes or no). These factors arose from the following research questions:

Questions from the orchardists

The three experimental factors chosen relate to pressing practical questions from fruit growers.

1. The first factor is **nitrogen level**. The orchardists are searching for an optimal fertilisation policy and optimal use of the biodynamic field preparations to reach a regular and moderately high production of tasty and storable apples and sustainable soil fertility. The fertilisation level needs to be high to sustain regularity of Elstar. Elstar is a variety susceptible to bi-annualism. The fertilisation level needs to be low for good fruit taste and storability. Both aspects are important in growing quality fruit. For fruit growers on different types of soils it is important to recognise properties of higher and lower fertilisation levels to search for their local optimum.
2. The second factor is the **type of fertilisers**. Dry commercial fertilisers, such as organic chicken manure pellets and Maltaflor (a waste product of conventional sugar and beer production), have practical advantages in application and in earlier nitrogen availability. This type of fertiliser is used more and more in organic production, but the growers who are keen on fruit quality have an uncertain feeling about the influence on soil and fruit quality. In this experiment we combined the two commercial fertilisers, chicken manure pellets and Maltaflor, to obtain an easy and cheap quick nitrogen supply at two different speeds. The third type of fertiliser was semi-composted cow manure, which should achieve a compromise between soil improvement and crop nutrition.
3. The third factor is **biodynamic field preparations.** After years of applying biodynamic field preparations with conviction, the orchardists would like to demonstrate the effect of the biodynamic field preparations to prove their efficacy to the customers and to know for their own benefit that they are using them in the proper way.

Hypotheses derived from the Inner Quality Concept

1. We assume that more fertilisation (expressed in nitrogen) will promote the growth processes and inhibit differentiation processes. Consequently we expect growth-related parameters to increase with nitrogen application or to show a saturation curve. We also expect differentiation-related parameters to show the opposite, with the consequence that parameters which influence the growth: differentiation ratio will shift.
2. We assume that composted manure will promote the integration processes in soil more than quickly mineralising commercial fertilisers. We expect more organic matter to be built up in the soil (Scheller et al., 1997 and many other authors). On the other hand, we expect that, for an apple tree, a high mineralisation in spring and a low mineralisation in late summer are optimal for production and for fruit quality (Dierend et al., 1996; Bloksma, 2003b). Consequently we expect more integration aspects in the trees with commercial fertilisers.
3. We assume that proper application of biodynamic field preparations will also promote the integration processes (Kolisko, 1939; Klett, 1968; Bockemühl, 1975; Bisterbosch, 1994; Lammerts v. Bueren and de Jonge, 1995). Consequently we expect to find the integration-related parameters to be higher and to find less variation at levels closer to the target range.
4. We expect properties in the harvested fruits to correspond to those previously found in the growing tree.
5. Do the three aspects of the quality concept, - growth, differentiation and integration -, arise from the experimental data as three distinct parameter clusters? Or in other words, can we find an experimental basis for the Inner Quality Concept besides the theoretical basis?

Parameter choice

Following the previous experiment in season I (2000-2001) and years of experience in apple growing we already had some ideas about the properties of growth, differentiation and integration processes. We therefore had a fairly precise hypothesis regarding parameters, as shown in the shaded blocks of the overview in §5.

This year we focused not only on the fruits, but also on soil and tree. We want to test the relationship between properties of the growing crop and the property of the resulting fruit. Some intended measurements were not carried out successfully for technical, capacity or financial reasons: e.g. fruit chroma, fruit rising pictures, copper chloride crystallisation from other laboratories.

4.2 Method

The orchard

Orchard conditions

Orchard ter Linde is situated in the south-west of the Netherlands, with a mild sunny sea climate with a slight salty spray from sea wind. The soil is limey humus sea loam on limey sand with trickle irrigation. The soil has been biodynamically cultivated for more than eighty years. A characteristic of this soil is the nitrogen retention; after fertilising, most nitrogen is humidified and not available for plant uptake. Nitrogen and potassium contents in leaves are always low in this orchard compared to other Dutch organic orchards and compared to aimed levels. Without spring frost it is an orchard with a relatively high production of good quality fruit. However, when spring frost occurs, trees are susceptible to bi-annual bearing because of low nutritional reserves. The details of the orchard and of the Elstar variety were described in the 2001 report.

Management measures in 2002

Mechanical weed control in spring, summer and after harvest. Fruit thinning by hand in June as homogeneous as possible. Removal of twigs with canker (*Nectria galligena*) by hand. Pest and disease control with agents for scab (*Venturia inasimilaris*), rosy apple aphid (*Dysaphis plantaginea)*, leaf rollers (several *Tortricidae*), apple sawfly (*Hoplocampa testudinea*), apple blossom weevil (*Anthonomus pomorum*). Fruit rot (here including mainly *Monilia, Gloeosporium, Nectria, Botrytis*) was not controlled and this was one of the few opportunities to prove resistance against pest and diseases.

Experiments in the orchard

We combined the three factors (fertiliser level; type of fertiliser and biodynamic field preparations) in a series with 6 fields: 1 field unfertilised, 4 fields with different levels of the standard fertiliser and 1 field with compost at a moderate level. We repeated these 6 fields in 4 blocks of which 2 were treated and 2 were not treated with biodynamic field preparations.

Nitrogen level is the limiting factor for fruit growing in this orchard. Therefore we defined the fertilisation regimes on the basis of nitrogen content. However the table below also shows the applied phosphate and potassium. Note: cow manure compost has a relatively high potassium content compared to the commercial fertilisers and the compost was only partly composted when applied in the orchard.

Table 5: Fertiliser application schedule 2001-2002

date	**fertiliser**	**applied kg N / ha only at the tree strip**					
	field number ->	1	2	3	4	5	6
19-4-2001	chicken manure pellets		20	40	60	80	
3-5-2001	Maltaflor		20	40	60	80	
3-5-2001	composted cow manure						100
total 2001		**0**	**40**	**80**	**120**	**160**	**100**
31-1-2002	chicken manure pellets		20	40	60	80	
26-4-2002	Maltaflor		20	40	60	80	
26-4-2002	composted cow manure						100
total 2002		**0**	**40**	**80**	**120**	**160**	**100**

Biodynamic field preparations

All the composted cow manure is prepared with the six biodynamic compost preparations (Steiner, 1924 / 1993), even in the blocks ‘without biodynamic field preparations’. The two biodynamic field preparations (cow manure and horn silica) are sprayed intensively in the orchard blocks ‘with biodynamic field preparations’. It was spraid low in the row to avoid drift to the untreated blocks. You will find more detailed information about the applications in annex 10.1 in the printed report.

Table 6: Experimental plots in 2001-2003

	applied in kg per ha and per year			**1= without BD field preparations**		**2= with BD field preparations**	
repetitions in the orchard A and B	**N**	**P**	**K**	**block A1**	**block B1**	**block A2**	**block B2**
1. unfertilised	0	0	0	A1-1	B1-1	A2-1	B2-1
2. chicken manure pellets + Maltaflor	40	21	34	A1-2	B1-2	A2-2	B2-2
3. chicken manure pellets + Maltaflor	80	42	68	A1-3	B1-3	A2-3	B2-3
4. chicken manure pellets + Maltaflor	120	63	102	A1-4	B1-4	A2-4	B2-4
5. chicken manure pellets + Maltaflor	160	84	136	A1-5	B1-5	A2-5	B2-5
6. composted cow manure (=100c)	100	41	114	A1-6	B1-6	A2-6	B2-6

In ha. of orchard, but applied at the tree strip i.e. over one third of the total area.

Layout of the experimental plots in the orchard

Thoughts behind the layout

Experiments with biodynamic field preparations are complicated because of uncertainty about how they work. There are some long-term experiments by the Forschungsinstitut für biologischen Landbau (Frick, CH) and the Institut für Biologisch-Dynamische Forschung (Darmstadt, D) that show clear and significant effects of long-term use of biodynamic field preparations, partly in combination with compost (Scheller et al., 1997; Raupp 2000; Mäder et al., 2002ab). But there are also many experiments which show no effect, maybe due to too small experimental size, too short application period, adverse context, etc. Because we expect that, for biodynamic field preparations, large plots are more likely to show an effect than many smaller plots, we opted for 2 treated and 2 untreated blocks of 33 x 50 square meters each. This is the first variable factor. In the middle of these four blocks we created six plots of 10 trees each, with each plot subject to a different fertilisation regime. This was the second variable factor. This meant that for each fertilisation regime, there were 2 plots which were located in BD field preparation blocks, and 2 plots in 'untreated' blocks. This brought the total to 24 plots of 10 trees in a split-plot layout.

Random layout in the orchard

One block was 33 m wide x 50 m long. The shaded blocks in the figure 7 below were treated with biodynamic field preparations over the entire surface. The rest of the orchard to the south-west side of this experimental area, being 3 ha, was also treated with biodynamic field preparations. Within the blocks the fertilisation plots (numbered from 1 to 6) consisted of 10 trees in a row. We used one tree in the row as a buffer between the fertilisation plots and 5 trees as a buffer between blocks.

Figure 7: Layout of the plots in the orchard

North-east

	block A1	**block A2**	**block B2**	**block B1**
	4 buffer rows	4 buffer rows	4 buffer rows	4 buffer rows
row 5	3 2 6	1 4 5	6 2 3	5 2 3
row 6	4 5 1	2 3 6	1 4 5	1 6 4
	4 buffer rows	4 buffer rows	4 buffer rows	4 buffer rows

grey parts are treated with biodynamic field preparations

more sandy subsoil ← *South -west* *→ more clay in subsoil*

Uncertainties in choosing the layout and timing of this experiment:

- We chose an experimental period of 2 years, but did not know how many consecutive years would be needed for the fertiliser regime to yield relevant results regarding long-term fertilisation policy. Before the experiment, the orchard was always treated with biodynamic field preparations and fertilised with a combination of composted cow manure and commercial fertilisers.
- We opted for at least 12 metres between evaluation trees sprayed with biodynamic field preparations and trees left untreated, but did not know if this buffer zone was sufficient.
- We chose to test for the effect of biodynamic field preparations over two years. We did not know if the two-year absence of biodynamic field preparations in the two 'untreated' blocks would be enough to show an effect.
- What is the relevant frequency, time of the day, way of preparing the biodynamic field preparations for this orchard? Together with the orchardists and a consultant specialised in biodynamic field preparations, we chose a general application policy in advance. The actual application is intuitively made depending on weather, stage of the crop and practical reliability, see Annex 10.1 of this report.

Observations

Repetitions in measurements

Parameters are measured in different ways: per tree, per box of fruits, per fruit, and repeated per block, per two plots (less intensive) or per plot (more intensive). Expensive measurements are carried out less intensively and cheaper ones are done more intensively. The key parameters were measured on all plots and the reference parameters are only applied to obtain an adequate reference to experimental results. See Annex 10.2 in this report for the whole list of parameters and each method, date and number.

Standardising fruits

At harvest we chose one picking date between the ‘first’ and ‘second’ commercial picking dates for this orchard. All trees bear very similarly thanks to strict fruit thinning in June. For analysis, all apples picked satisfied the following standards: 70-90 mm diameter, whole or half sun-exposed, unblemished, picked at medium height in the tree, from trees growing normally (no severe canker, no blown-down trees in recent years). We had a minimum of 80 standard fruits per plots. The apples for the three months cold storage were picked one day later and included all the non-standard sound apples per plot from trees growing normally (about 150 / plot). This second picking provided information about fruit size (which had been fixed in the first picking).

Check on similar ripening rate

Nitrogen level and biodynamic field preparations may influence the ripening speed. In literature examples are mentioned of earlier and later ripening due to higher nitrogen levels. We checked this in our experiment by picking fruits every week for 6 weeks before the picking date and measuring the ripeness in the same way as growers determine their optimum picking date, see CD-ROM 9. The conclusion was that fruits from all trees ripen at more or less the same rate. This is an important condition for an experiment with one picking date.

Table 8: Picking date, storage and shelf-life conditions

date	conditions
19-9-2002	picking samples for direct measurements, directly put in cold storage Orhard ter Linde 5 °C
20-9-2002	picking samples for storage, directly put in cold storage Orhard ter Linde 5 °C
23-9-2002	samples to lab ZVI and 25-9 analysis after harvest: firmness, Brix, acidity
23-9-2002	cooled transport to Randwijk for 12 weeks of mechanical cold storage: first 2 weeks 2 °C; then 10 weeks 1,3 °C
17-12-2002	cooled transport to cold storage Orhard ter Linde 5 °C
19-12-2002	cold storage Orchard ter Linde 1 °C and on 20-12-2002 analysis of storage diseases
3-1-2003	transport to LBI and one night in cold storage 4 °C
4-1-2003	start shelf life at about 18 °C
8-1-2003	samples for analysis PPO: firmness, Brix, acidity after 5 days of shelf life samples Fulda: sensory properties after 5 days of shelf life
13-1-2003	samples for analysis PPO: firmness, Brix, acidity after 9 days of shelf life

The seasons 2001, 2002, 2003

In fruit growing, fertilisers and maybe also biodynamic field preparations are taken slowly into the trees, so we started these applications in 2001 and continued into 2002 and in 2003. We did crop and soil observations in 2002 and 2003, and fruit observations only of the 2002 harvest.

Table 9: Description of weather conditions in 2001-2003

2001	Warm and wet winter, heavy night frost during bloom and less fruit set, cool wet summer, hot August and again a wet autumn.
2002	Early bloom and early harvest, wet and warm summer promotes growth (in general somewhat above optimum), dry and warm autumn promotes differentiation, a really good season for apple growing. A salt sea spray from an autumn storm (27 Oct) suddenly ended the growing season, most severe in block B1.
2003	After a mild winter 2003 started with an extremely dry spring with some night frost at the beginning of April.

4.3 First evaluation of the quality of the experiment

The experiment was very well managed

The orchardists carefully attended to the rows for 2 years: fruit thinning to similar bearing, similar pruning, similar pest and disease management, similar weed control and similar watering. In 2001 we checked by means of some observations (vigour, flowering, leaf analysis, fruit analysis) the homogeneity of the field and the extent to which the plots reflected the different regimes. It would have been even better to start the treatments two years earlier. We saw in another fertiliser experiment at this orchard that clearer differences appeared after 3 years. It was useful to have one season beforehand to minimise undesirable variations in a perennial crop by cultivation.
We were lucky with the 2002 harvest season. It was a fine season for apple growing in this orchard without spring frost. Weather promoted both growth and differentiation and the orchardists were satisfied about quantity and quality.

Check on field effects

As in all orchards where we do fairly large-scale experiments, we have to accept some confounding influence from the variation in conditions in the experimental field, i.e. field effects. In the first year we controlled for differences between plots with the same regime and between different treatments (by means of crop observations, and bud, leaf and fruit analysis) and concluded that the influence of fertilisation was much greater than the influence of different conditions in the plots. In the second year, the first block showed greater differences from the other three blocks than in the first year and this had dramatic consequences for our conclusions about biodynamic field preparations. Block A1 is a little sandier in the subsoil and the last block, B1, is has more clay in the subsoil, see figure 10. In §6.1 we examine the results of this field effect before we discuss the effects of fertilisers and biodynamic field preparations.

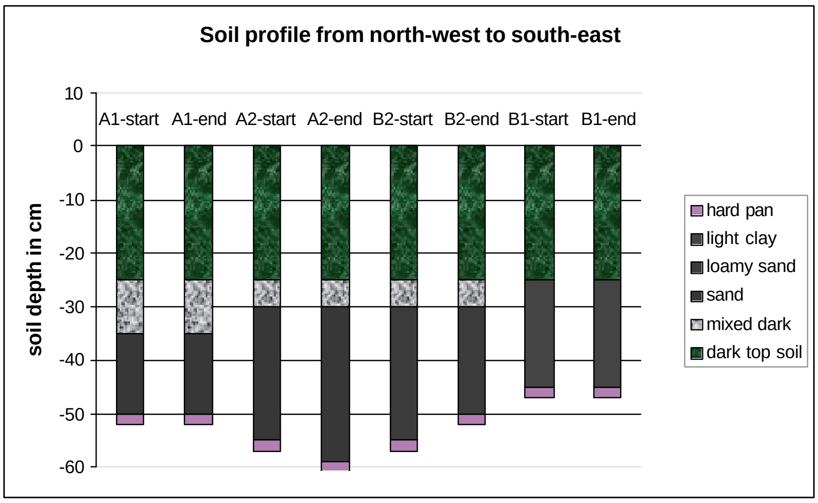


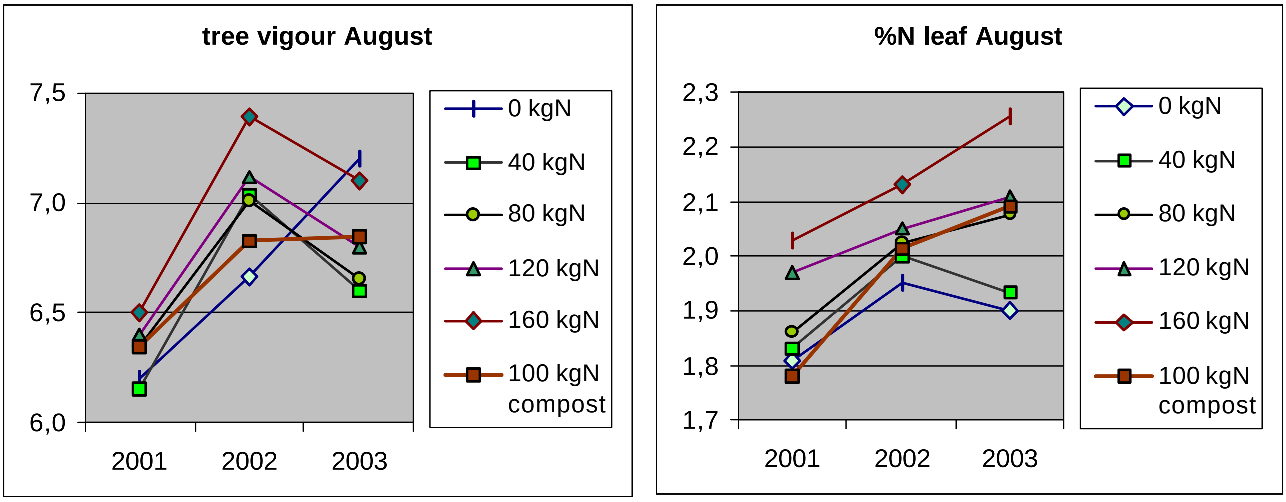
Figure 10: Soil profile in the experimental field

Because of these differences between blocks, we often present figures separately for each block on the CD-ROM. Because the two outside blocks (A1 and B1) happened to be the blocks which were not treated with biodynamic field preparations, we cannot prove the interesting hypothesis that the use of biodynamic field preparations leads to greater uniformity.
In the case of parameters of mixed samples for both replicated blocks together, it is not possible to draw any conclusion about the influence of biodynamic field preparations because of the influence of the sometimes deviant behaviour of block A1. So we only evaluate the influence of biodynamic field preparations for parameters applied in each of the blocks.

Fertilisation series did not produce anticipated extremes

While about 80 kgN / ha is a common fertiliser level for organic orchards, we anticipated that after 2 years with 160 kgN / ha per year we would find an over-fertilised soil, and a rather poor soil where no fertiliser was applied. In the soil, all the fertilisation levels had low mineral nitrogen content (< 3 ppm N-min), although the content increased in line with the fertilisation level (see CD-ROM 1d).
After two years, the unfertilised trees indeed proved poor in leaf quality and vigour. The most fertilised trees had more green leaves and these were bigger and had more vigour (see below figure 11 and 12). The moderately fertilised trees (40, 80, 120 kgN per ha) were fairly similar. The high vigour of the unfertilised trees in 2003 is due to very little bearing due lack of nutrients. For many parameters, the fertilisation series show a consistent line, but without the large differences we expected. Apparently the buffering capacity of soil and the trees level out the extremes of fertilisation. We see more extremes in soil and trees than in fruits. See the overview in §5.

Figure 11 and 12: The development of tree vigour and nitrogen in leaves in 2001, 2002 and 2003.



Few differences between types of fertilisers

At first, the trees in plots with composted cow manure proved as poor as the unfertilised trees, but later they resembled the moderately fertilised trees. This result is expected from slow release fertilisers. The compost regime had advantages and disadvantages compared with the commercial fertiliser regime which supplied a similar quantity of nitrogen, see the overview in §5. The quality of the applied compost is not as good as we had hoped for the 'integration' process.
In a blind analysis, Ecosys, the laboratory that made chromas of the manure, identified the partly composted status of this compost, see CD-ROM 4ab. However, they assessed this compost as a much better fertiliser for soil life than both commercial fertilisers.

Hardly any differences between the blocks with and without biodynamic field preparations

On most parameters blocks with or without biodynamic field preparations did not differ significantly, see the overview in §5. We speculated about the reason: was the experiment too small-scale? Did treated blocks influence untreated blocks? Are the biodynamic field preparations in the untreated blocks still active after 2 years? Were the biodynamic field preparations applied in a relevant way for this orchard? Can the effects of biodynamic field preparations only be recognised by means of other type of measurements?
Some parameters showed significant differences between the 2 treated blocks with and the 2 untreated blocks,

but it is not certain that this was caused by the biodynamic field preparations, because of the presence of field effects.

Samples did not have sufficient homogeneity for all parameters

When differences between the trials are smaller than expected, homogeneity in the samples is of great importance. Several laboratories asked for larger samples after the set-up of the experiment. We could not meet this demand without being less strict about the standard of sampled fruits. After all, it would have been better to omit analyses than to decrease the standardisation of the fruits. However, many conventional tree and fruit parameters show a nice consistent line (see chapter 6.2) and this means there was sufficient homogeneity for these parameters.

5 Overview of hypotheses and results for the different parameters

In the next table you will find an overview of the measured parameters, the hypotheses and results. On the CD-ROM each parameter is described in terms of background, method, statistics, results, correlations and relation to growth, differentiation and integration.

Key to table 13:

Arrows:
Examining all the results of the individual parameters (graphics on the CD-ROM) we could group them as follows:

1. in the fertilisation series we distinguish: an increase (arrow up), a maximum (arrow up-down), a decrease (arrow down), a minimum (arrow down-up) or no effect from increasing fertilisation (horizontal arrow).
2. in the comparison between compost and commercial fertilisers we distinguish: higher (>), lower (<) and similar (=).
3. in the comparison between use or non-use of biodynamic preparations we distinguish: higher (>), lower (<) and similar (=).

We distinguish several degrees of certainty:

x significant (with 95% certainty from statistical analysis, see annexes on the CD-ROM) and scientific explanation exists.
x? significant, but unexplained by theory, or no theory available.
o clear trend (= a consistent line, but not significant due to excessive variation).
(o) insufficient data for a conclusion (as in the case of some parameters that are included for a first exploration, or to indicate the level for the context, insufficient number of plots).

Grey cell indicates our **expectation** before the experiment, based on existing knowledge of apple growing.

Remarks:
1) Some parameters are indicated as ‘standard’; this means the parameter should be constant as a check for homogeneity.
2) For some parameters, results from one block deviated from the rest. This block is mentioned here with an indication of systematically higher (>) or lower (<). The (significant) differences found may be partly due to this field effect and not only to biodynamic field preparations.

Table 13: Overview of hypotheses and trends for all parameters

CD-ROM no.	Parameter	increasing N					compost / commercial fertilisers			BD field preparations: yes / no			remarks 1), 2).
		↗	↗↘	↘	↘↗	→	>	<	=	>	<	=	
Soil													
1	organic matter					o	o					(o)	
“	respiration				o				o			(o)	
“	available K	o					o					(o)	
“	reserve K					o			o	(o)			
“	available P	o							o	(o)			
“	reserve P					o			o	(o)			
“	N-min. Nov. ‘02	x					x					(o)	
2bc	chroma overall assessment		(o)				(o)					(o)	
2d	micro life: fungi / bacteria					(o)	(o)					(o)	

CD-ROM no.	Parameter	increasing N					compost / commercial fertilisers			BD field preparations: yes / no			remarks 1), 2).
		↗	↗↘	↘	↘↗	→	>	<	=	>	<	=	
3	leaf decomposition					x	x			x			block A1<
“	weed growth	x						x				x	
Tree													
5ac	flowering ’02		o						x			o	standard
5a	fruit bearing ’02					o			x			x	standard
5ac	vigour ’02	x						o				(o)	block A1<
5bc	growth terminated			x			o					x	
“	leaf quality ’02	x						x				x	block A1<
--	autumn colouring ’02					(o)			(o)			(o)	
21bc	aphid ’02					(o)			(o)			(o)	
5de	flowering ‘03	x						x				x	
“	hand thinning ’03	x						o				x	
“	bearing ’03	x							x			x	
5de	leaf quality ’03	x							x			x	
“	vigour ’03				o				x			x	
“	% trees in balance		x						x			x	
6	length ‘02	o						o				-	
“	leaf size ‘02	o						o				-	
7ab	cluster leaf % N July ’02	x							x			x	block A1<
“	cluster leaf % K July ’02			x			x					x	block B1>
7cd	twig leaf % N Aug ’02	x							o			x	block A1<
“	twig leaf % P Aug ’02			x					x		x		block A1>
“	twig leaf % K Aug ’02			x					x			x	block B1>
“	twig leaf % Mg Aug ’02	x							x			x	
“	twig leaf % Ca Aug ’02	o							x	x			block A1>
7ef	twig leaf % N Aug ’03	o					o					o	
“	twig leaf % P Aug ’03			o			o					o	
“	twig leaf % K Aug ’03			o			o					o	
“	twig leaf % Mg Aug ’03	o						o				o	
“	twig leaf % Ca Aug ’03					o	o			o			
8ac	flower bud % N March ’02	o							o			(o)	
“	flower bud % P March ’02					o			o			(o)	
“	flower bud % K March ’02	o							o			(o)	
8bc	flower bud % N March ’03	x							x			x	
“	flower bud % P March ’03					x			x			x	
“	flower bud % K March ’03	x							x			x	
Fruit													
9	ripening speed					x			x			x	standard
10	weight (not standard)	o							x			x	
“	% blush			x			x					x	
--	ground colour					o			o			o	
--	shine					o			o			o	
--	russeting					o			o			o	
11ac	firmness			x					x			x	block A1>
“	disappeared starch			x					x		x		
11bd	sugar in Brix					x			x			x	
“	malic acid	x							x			x	

CD-ROM no.	Parameter	increasing N					compost / commercial fertilisers			BD field preparations: yes / no			remarks 1), 2).
		↗	↗↘	↘	↘↗	→	>	<	=	>	<	=	
“	Streif-index			x?					x		x		block A1>
11ac	number of seeds			x			o					x	
12ac	dry matter	x							x			x	
“	N	x						x				x	block A1<
“	P					x	x			x			block A2 >
12bc	K					o			x	x			
“	Ca			o			x					x	
“	Mg	x							x	x			
13ab	free amino acids	x							x			(o)	
“	protein	x							x			(o)	
“	% protein			x					x			(o)	
14ab	total phenols			x					x			(o)	
14ac	vitamin C					o			o			o	
15bc	sourness (Fulda)	x						o		o			
“	sweetness			o		o			x		o		
“	crispness				o				x	o			
“	all odours					o			x			o	
15bc	all flavours					x			x			o	
“	all texture					o			x	o			
“	sweet+sour+crisp		o						o	o			
“	bitter+astringent		o						o	o			
15ef	overall taste (Järna)			(o)			(o)					(o)	
16bcd	growth in CC-crystallisation	x						x				(o)	
“	differentiation CC-crystall.			o		o			x	(o)			
“	integration in CC-crystall.					x			x	(o)			
17bc	Meluna initial value		o			o			x			x	
“	Meluna hyperbolicity				x?				x			x	
18ab	Kwalis R40W	x						o		x?			block A1<
“	Kwalis R40Y / B			x					o			(o)	
“	Kwalis ChiE / H50R		o						o			(o)	
19ab	acidity (pH)					o			o			(o)	
“	redox potential (Eh)					o			o			(o)	
“	elec. resistance (R)					o			o			(o)	
“	P-value					o			o			(o)	
“	dissipation (Dp-value)					o			o			(o)	
20ab	shelf life after storage					o			o			(o)	
--	softness after storage					o			o			o	
21a	scab after storage	(o)							-	(o)			block A1<?
“	leaf roller	(o)										(o)	
21bc	fruit rot after storage	o							o	x			block A1<?
22ab	Botrytis after inoculation	x							o			(o)	

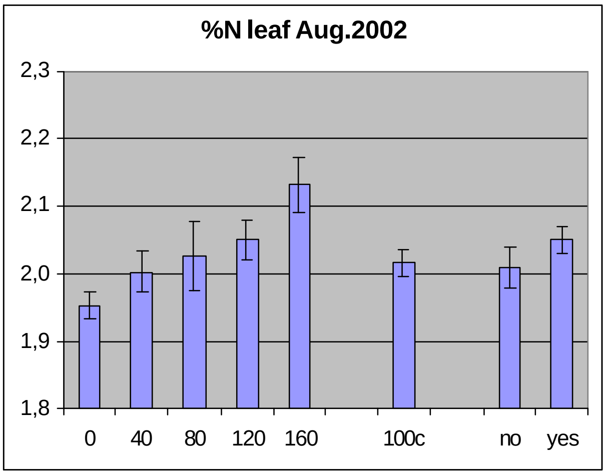
6 Discussion of the experimental factors

6.1 Field effects

First in this chapter, we evaluate the unintended variation between the fields. The soil differences are described in §4.3 and figure 10 the deviating blocks are mentioned in table 13 in §5. There was no systematic deviation for any particular block for the parameters not mentioned.

The subsoil in the first block in the row, block A1, is a little sandier, which corresponded with less N-uptake, less vigour, fewer green leaves, less nitrogen in leaf and less leaf decomposition. Consequently the fruits were a little firmer and contained more calcium and phosphor, less nitrogen and probably suffered less fruit rot. Kwalis found a lower R40W-value in spectral range luminescence (CD-ROM 18b). All these factors consistently indicate a lower growth level. See fig. 14 and 15 for examples.

The last block in the row, block B1, has a subsoil with a little more clay, which corresponded with some incidental deviations, but these were not consistent or strong.



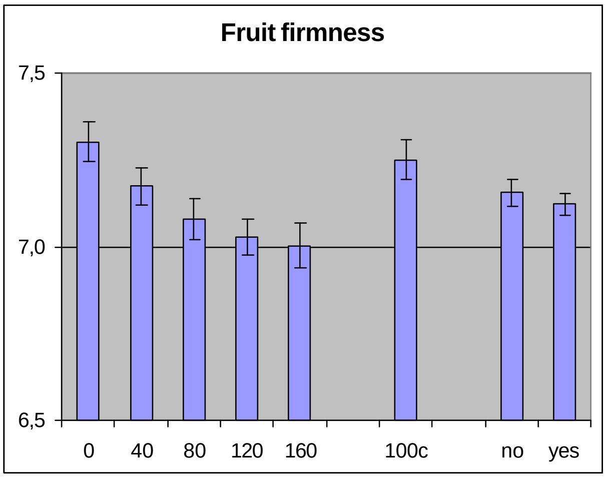


Figure 14 and 15: Variation between block A1 and the other blocks in nitrogen in leaf (Aug. 2002) and fruit firmness (harvest 2002) in the 4 blocks.

6.2 Fertilisation level

About the series

Section §4.3 gives the initial evaluation of the fertilisation range. After 2 years we indeed obtained a series from too low to too high in fertilisation as desired, but effects of this were not as extreme as we expected. We saw greater extremes in soil and trees than in fruits. Tree vigour and leaf quality react more sensitively to fertilisation than fruits. The poorer and sandier the soil by nature, the greater the impact of fertilisation.

In 2002 the trees with moderate levels (40, 80, 120 kgN per ha) looked fairly similar and optimum in fruit growers' eyes. But in 2003 large differences appeared in fruit set and 120 kgN was the best.

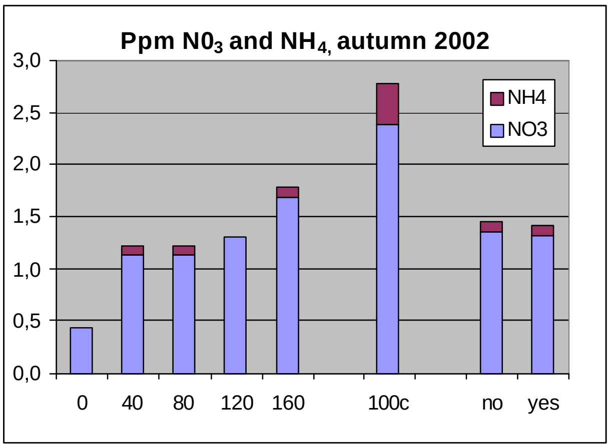
Many parameters showed a consistent line for all blocks confirming the existing knowledge about fertilisation of apple (such as tree vigour, leaf quality, minerals in leaves, fruit blush, fruit weight, fruit firmness, fruit minerals, malic acid, disappeared starch). This makes it possible to draw conclusions and indicates that fertilisation is a causal factor.

Soil properties

With a higher fertilisation level we saw more available nitrogen (fig. 16), phosphor, potassium in soil and more weed growth (fig. 17). We did not see any difference in organic matter, reserves of phosphor and potassium, soil respiration or soil life. Soil parameters are measured less accurately i.e. only to assess the level and not to demonstrate differences between the treatments. Soil chromas showed an optimum at 80 kgN.

The unfertilised plots had a slower decomposition rate than fertilised plots, but scores were similar on 1 April. Fertilisation did not speed up decomposition as we expected, although autumn fertilisation might.

The increase in weed growth is a concern for the fruit grower. In wet springs he would not be able to hoe the grasses in time, which could result in decreasing mineral uptake with increasing fertilisation because of greater competition from weeds.



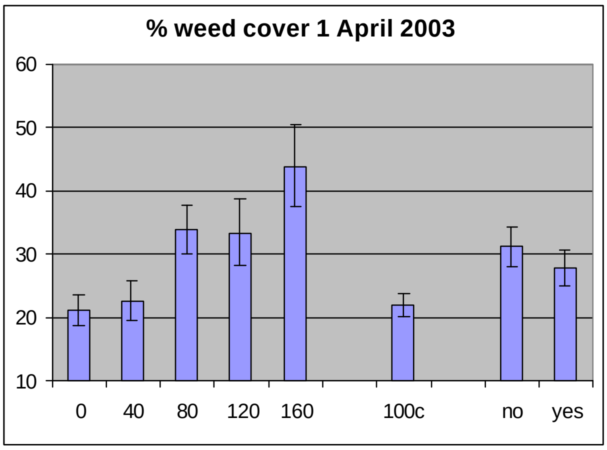
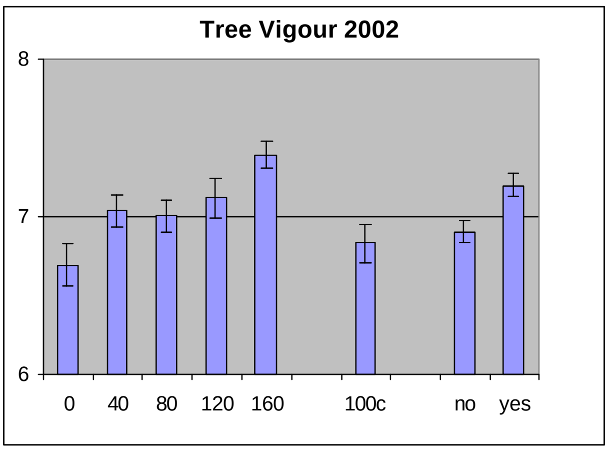
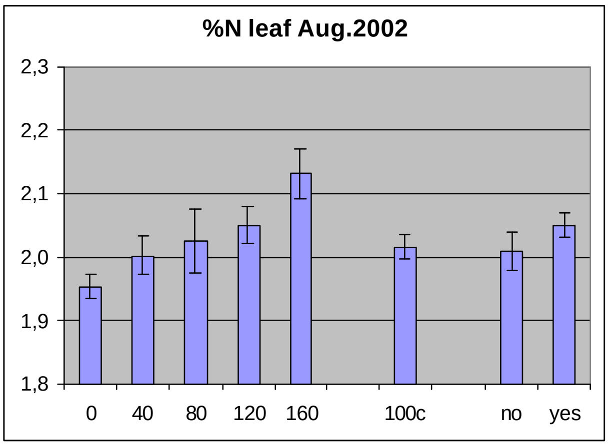


Figure 16: Nitrate in soil was always low, mostly below detection level. In Autumn 2002 it showed the expected increase with higher fertilisation.
Figure 17: Weed cover increased with higher fertilisation with commercial fertilisers, but not with compost.

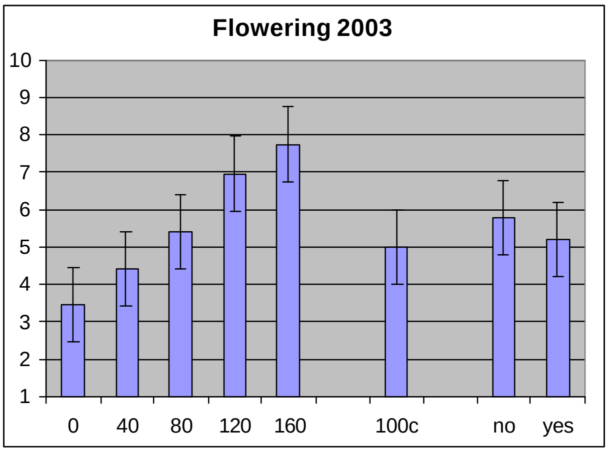
Tree properties

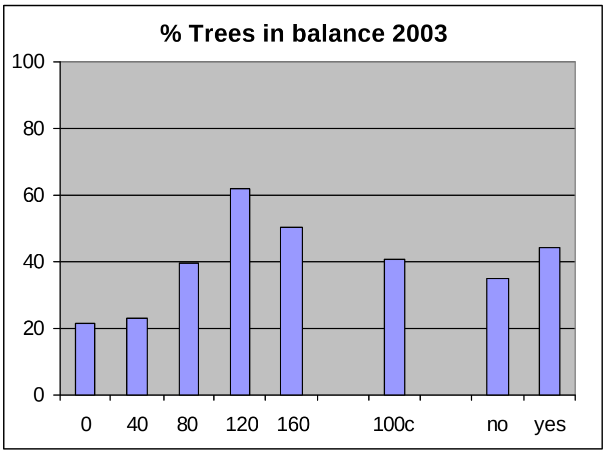
In 2002, with a higher fertilisation level, the trees showed more vigour (fig. 18), later termination of twig growth, longer twigs, more flower bud formation for the next year (fig. 20), which should result in higher gross yield in 2003. Leaves were darker green in colour and larger in size with more nitrogen (fig. 19), and magnesium and less phosphor and potassium. Flower buds had higher levels of nitrogen, potassium and similar levels of phosphor. The highest number of trees with balanced bearing and growth in 2003 are found at 120 kgN (fig. 21).





Figures 18, 19: Increasing tree vigour (2002) and nitrogen in leaves (Aug. 2002) with increasing fertilisation.





Figures 20, 21: Increasing flowering (2003) and optimum in tree balance (2003) with increasing fertilisation.

Fruit properties

At higher fertilisation levels the fruits were bigger in 2002 with less blush (shade with greater vigour), they were less firm (competing twig growth, fig. 15) and lost their starch reserve more slowly. The fertilisation level had no influence on sugar (Brix) and phosphor. With a higher fertilisation level the apples contained more dry matter, nitrogen, magnesium, malic acid (fig. 22) and less calcium (fig. 24), fewer phenols (fig. 25) and fewer seeds. Fewer seeds are the contrary of what we expected, see discussion in CD-ROM 11e.

The ripening rate in the weeks before harvest was similar. The lower Streif-index with more fertilisation may not be interpreted as riper, but as softer. At higher fertilisation level the apples were less 'ready' at harvest. They still contained more metabolites such as amino acids (fig. 30) that were not converted into protein (fig. 31). This is as expected from the background, see CD-ROM 13c, Schuphan (1976) and Chaboussou (1987).

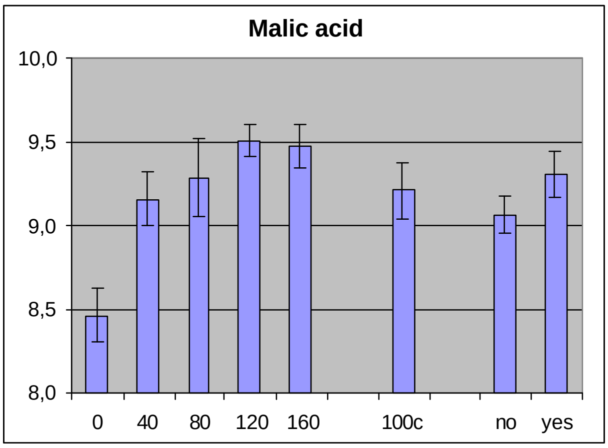
After storage we saw fewer differences: only apples from the highest fertilisation level had more natural fruit rot (fig. 26) and were more susceptible to Botrytis rot after inoculation (fig. 27). The shelf life was similar.

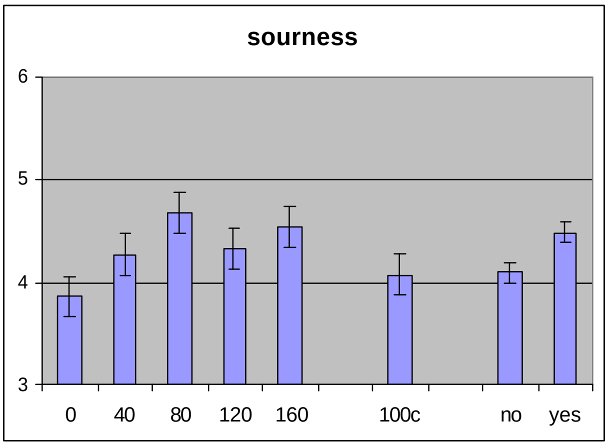
At a higher fertilisation level the apples in Fulda tasted a little more sour (fig. 23) and were similar in other taste attributes, including aroma. More tartness in taste is consistent with higher malic acid content in fruit analysis.
In Järna the overall appreciation of taste was the best in unfertilised in terms of better aroma, experience of light and roundness and good integration of tart and sweet taste.

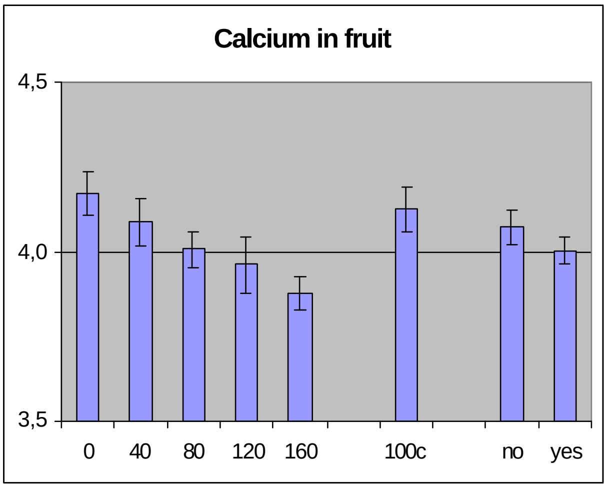
At a higher fertilisation level the copper chloride crystallisation pictures of fruit juice showed more growth (increased perradiation and fullness with side needles; fig. 28), tended to less differentiation (less centre co-ordination and more multi-centred pictures) and were similar in integration (coherence).

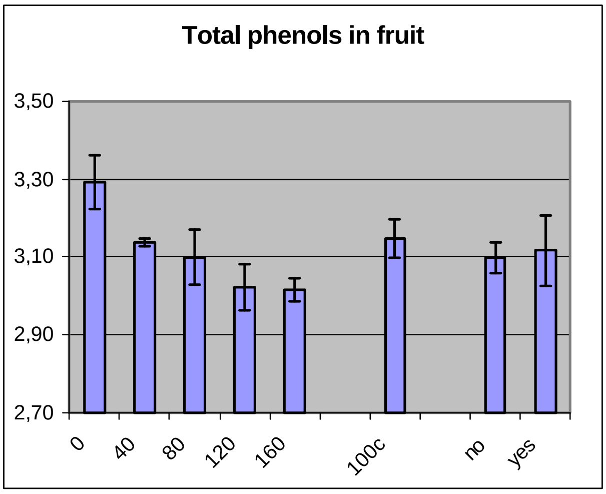
The spectral range luminescence parameter R40W showed an increase, as expected from a growth parameter (fig. 29). It was much lower in the poorest block A1, as expected. Parameter R40Y / B showed a slight decrease as expected from a differentiation parameter. The spectral range luminescence parameter ChiE / H50R was similar with one higher value for moderate fertilisation (80 kgN), as expected from an integration parameter. This fertilisation series confirms the hypothesis referred to above about how to recognise growth, differentiation and integration in both copper chloride crystallisation and spectral range luminescence.

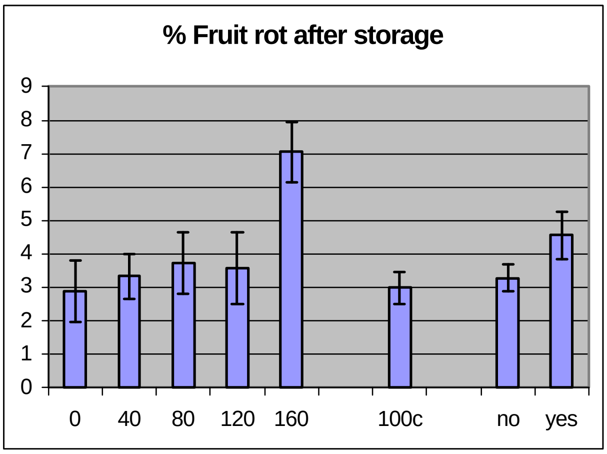
At a higher fertilisation level we did not see any interpretable differences in delayed luminescence by Meluna and the electro-chemical parameters.

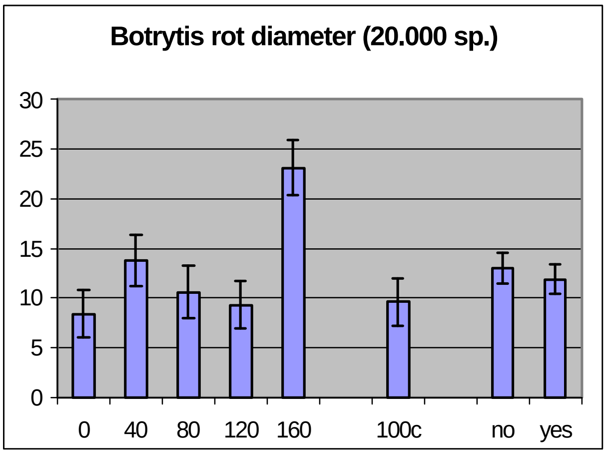








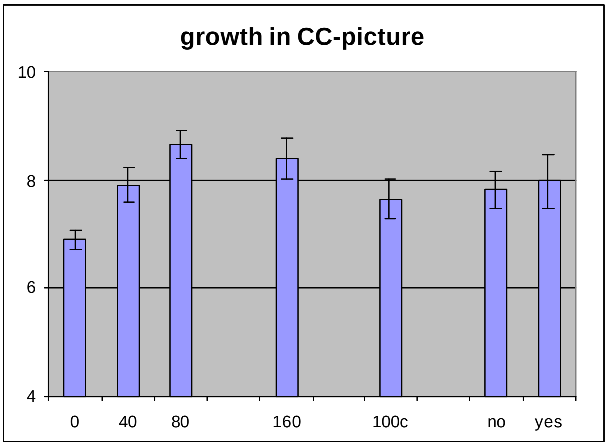


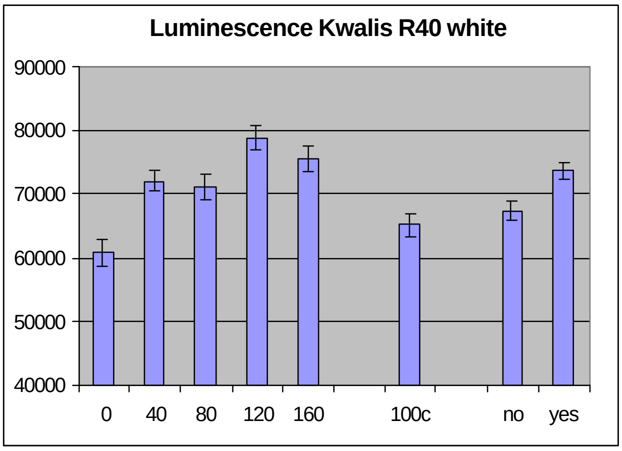


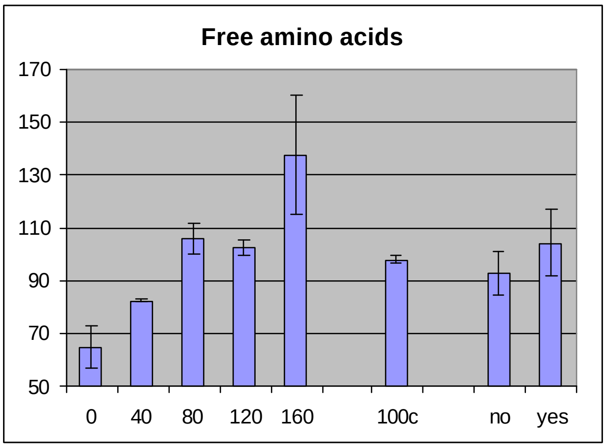
Figures 22 and 23: Increasing malic acid content and sourness in taste (Fulda) with increasing fertilisation.

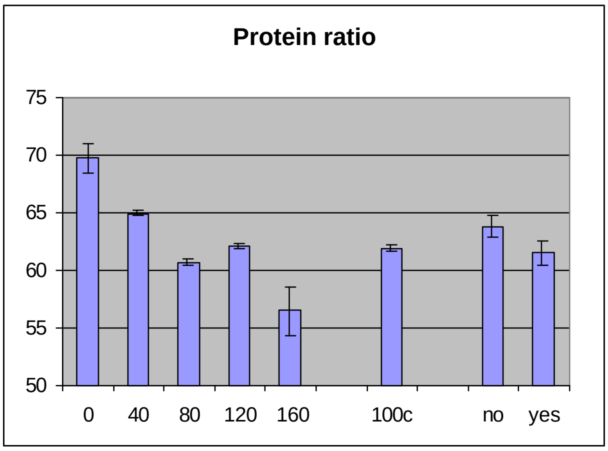
Figures 24 and 25: Decreasing calcium and phenols content with increasing fertilisation.

Figures 26 and 27: Both more natural fruit rot and Botrytis rot after inoculation at the highest fertilisation level.









Figures 28 and 29: Increasing growth scores in CC-crystallisation and in spectral range luminescence (R40W score Kwalis) with increasing fertilisation.

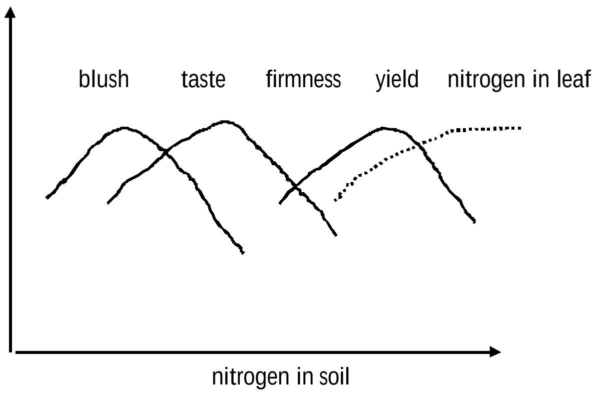
Figures 30 and 31: Increasing free amino acids content, but decreasing protein ratio (this is % incorporated protein as a measure of how 'finished' the product is) with increasing fertilisation.

Overall

From literature we know there is no single best nitrogen level. Many properties have their own optimum. For example, blush, taste, storability, texture, yield are best at successively higher nitrogen levels, see fig. 32. Fruit growers can choose what aspects they would like to emphasise.

The hypothesis about higher fertilisation levels was that growth will increase, differentiation will decrease and integration will find an optimum between 80 and 120 kgN / ha. Most of the properties indeed consistently confirmed this, see table 35 in §7.

Figure 32: Different properties are best at different nitrogen levels (Friedrich and Fischer 2000).



6.3 Type of fertiliser

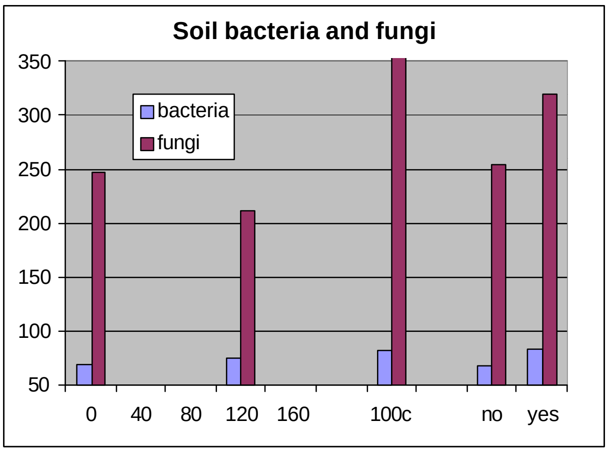
About the series

Compost is compared with commercial fertilisers at different fertilisation levels. These series showed the dynamics of releasing minerals and the balance of growth and differentiation. The results confirmed the known slow release of minerals from compost. This made it possible to draw conclusions and to confirm that the fertiliser is a causal factor. Applications of composted cow manure produced some more potassium in balance to nitrogen than the commercial fertilisers (see §4.4) but increased potassium was only found once in leaves and not at all in fruit analysis.

Soil properties

After 2 years of compost applications we saw a higher organic matter content, more available potassium and nitrogen in the autumn and more soil life (fig. 33), better soil chroma and quicker leaf decomposition (fig. 34). Compost dressings add diverse microlife to the soil, and as expected, leaf decomposition was more rapid in plots with the compost regime, except plot A1 which was a little sandier. The literature gives ample evidence of the positive effect of compost and stable manure on apple leaf decomposition (Groß-Spangenberg 1992; Krüger 2000. etc). In apple growing, the decomposition rate of fallen leaves on the soil has influence on overwintering scab fungi in the leaves. An active soil microlife and the worm *Lumbricus terrestris* help to break down and digest the leaves. The aim is to have the leaves decomposed before March when new leaves appear. For decomposition in this orchard, soil life is of more importance than nitrogen content in the fallen leaves.

We did not see differences in available phosphor, reserves of phosphor, potassium and soil respiration.
Weed growth was strikingly low in the fields with compost and similar to unfertilised (fig. 17), although the mineralisation in the preceding autumn was high in the composted fields.



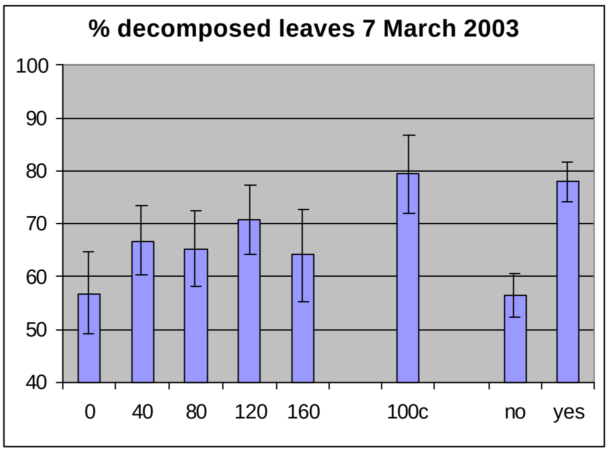


Figure 33 and 34: Quicker leaf decomposition and more soil life in the fields with compost.

Tree properties

In the beginning the trees with composted cow manure proved as poor as the unfertilised trees, but later they resembled the moderately fertilised trees. This is demonstrated in §4.6 with figures 11 an 12 showing tree vigour and leaf nitrogen.
After 2 years of compost applications the trees were still retarded in growth (vigour, twig length, termination, leaf quality and flower bud formation, see figures 18, 19, 20). After 3 years the composted trees were similar on these points. Leaf analyses in 2002 showed only potassium was higher and in 2003 most mineral levels tended to increase. Also flower bud analyses were similar.

Fruit properties

Fruit from the composted fields were distinguished by more blush, more phosphor and calcium, and tended to have more seeds and vitamin C and less nitrogen. The fruits were similar in ripening rate, weight, fruit rot, firmness, starch, Brix, malic acid, amino acids, protein, phenols, dry matter, potassium and magnesium. The taste was fairly similar: the Fulda panel tended to find these apples sweeter and less acidic, while the Järna panel gave a better overall assessment, similar to apples from unfertilised plots: more intense taste, well integrated sweet / tart and with typical apple taste.

The delay in growth we saw in the tree properties was again observed in the copper chloride crystallisations, but differentiation and integration were similar. Kwalis associated the delayed luminescence with delay in growth and also evaluated differentiation and integration as similar.

The CC-crystallisations from compost apples appeared to be the most chaotic of all, which we did not expect. No differences were found in delayed luminescence by Meluna, electro-chemical measurements or in shelf life after storage.

Overall

We anticipated that compost would release nutrients more slowly than the commercial fertilisers used. This results in a delay in growth but later in the season or after some years growth will match or exceed growth in plots receiving the same kg N / ha in the form of commercial fertiliser. Some growth parameters showed a similar value to that found for unfertilised plots and some resembled results on plots with moderate levels of commercial fertiliser applications. We also expected compost to result in more integration for soil parameters, i.e. increased soil life, greater decomposition of leaves and a tendency to better taste. For fruit properties we had two opposite expectations about the effect of compost: 1. more integrated soil will improve integration in fruit and 2. more nutrient release in the late summer will decrease ripening and integration. We found fewer differences in fruit properties, so maybe both expectations are true.

6.4 Biodynamic field preparations

About the series

This factor was the weakest of the three factors because of the small number of independent blocks (1 or 2 depending on the parameter), the field effect and the doubts about the experimental design evaluated in §4.6. Also, there is insufficient knowledge about the effect of biodynamic field preparations. Some parameters showed significant differences between the 2 blocks with and the 2 blocks without biodynamic field preparations, but in this experiment we could not conclude whether this effect was caused by the biodynamic field preparations. Neither we could conclude that biodynamic field preparations had any effect at all.

However, each case is worth documenting to collect experience about this treatment. The description below has the status of a case description of the differences between the blocks with and without biodynamic field preparations, and do not rule out the possible causal nature of the field effects. It should be noted that, strictly speaking, we investigated the effects of two years of abstaining from BD field preparations, rather than the effects of two years of use.

Soil properties

In the blocks with biodynamic field preparations we saw significantly more available phosphor and more phosphor and potassium in soil reserves and quicker leaf decomposition (fig. 33).

Tree properties

We found very few differences in tree properties: only less calcium in leaves in 2002 and in 2003.

Fruit properties

In fruit we hardly found any differences. The few differences were rarely significant because of the small number of blocks, and they were not consistent. In the blocks with biodynamic field preparations we found more phosphor, potassium and magnesium in the fruit, more fruit rot after storage, a tendency to better taste in Fulda, but not in Järna. In the CC-crystallisations there was a tendency to greater differentiation and integration, but not to growth. In spectral luminescence tests by Kwalis the opposite was found: a higher R40W value, which is considered to be an indicator for growth. Thus the overall conclusion is that we do not find consistent differences in fruit properties.

We were surprised to find the pictures of BD field preparations look stiff, not showing any organic liveliness or 'organische Beweglichkeit'. The rather chaotic pictures of apples from the compost plots were clearly more ordered and more integrated in the blocks with BD field preparations than the blocks without BD field preparations. This was in line with what we expected from BD field preparations, but the causing factor is uncertain, as discussed earlier.

Overall

We found no clear influence of two years without biodynamic field preparations in two 33x50 m blocks of orchard in soil, trees or fruits. For most properties, treated and untreated blocks scored similarly. There were some differences and some tendencies which were in line with our hypotheses about biodynamic field preparations: higher decomposition of leaves, more phosphor and potassium in soil reserves, better taste, more differentiation and integration in the copper chloride crystallisation pictures. However, more fruit rot was not expected.

7 Discussion about parameters and life processes

7.1 Overview

Based on the results in the previous study and in this apple study and the generally accepted parameters (Golden Standards) for life processes, all parameters are evaluated as an indication for growth, differentiation or integration. When we know which life processes are related to which properties, fruit growers have the opportunity to take early management measurements to regulate fruit quality in the crop growing phase.
One parameter can express both growth and differentiation depending on which factor is limited.

For the integration of growth and differentiation we only had two Golden Standard parameters (taste and absence of pests and diseases). Neither showed large differences in these studies, so it was not possible to draw conclusions for experimental integration parameters.

We present an overall evaluation in table 35, then we discuss some specific parameters.

Key to table 35:

shading indicates hypotheses based on literature
X = assumed Golden Standard parameter for this process
x = high correlation with Golden Standard parameter found in one of the apple studies
o = moderate correlation with Golden Standard parameter found in one of the apple studies
? = with some uncertainties

Table 35: An overview of progress in finding life processes and parameters.

Parameter	**§ apple study 1**	**CD-ROM apple study 2**	**growth**	**differen-tiation**	**inte-gration**	**conditions**
Soil						
organic matter	-	1		-		long term only (not in this study)
respiration	-	1			-	
available K	-	1	**X**			
reserve K	-	1		o?	o?	
available P	-	1	**X**			
reserve P	-	1		o?	o?	
N-mineral	-	1	**X**			rarely high enough in org. orchards
chroma overall assessment	-	2a-f			o?	method needs more validation
micro life: fungi / bacteria	-	2g-i			o?	method needs more validation
leaf decomposition	-	3			x	
weed growth	-	3	o			no weed control
Tree						
fruit bearing	-	5	**X**			standardisation of fruit bearing and vigour previous year
vigour	-	5	**X**			standardisation of fruit bearing
terminated twigs	-	5	**X**			standardisation of fruit bearing
leaf quality	-	5	**X**			standardisation of vigour
aphid	-	21b	o			no pest control
flowering	-	5	x			standardisation of bearing previous year and if fertilisation is limited
flowering	-	5		x		standardisation of bearing previous year and if light exposure is limited
empathic balance	-	5			-	method needs standardisation, see Cd-Rom 5f

Parameter	§ apple study 1	CD-ROM apple study 2	growth	differen-tiation	inte-gration	conditions
% trees in balance next year	-	5			x	
autumn colouring	-	5		-		undisturbed ripening (not in this study)
length in leaf series	5	6	x			
leaf size in leaf series	5	6	x			
cluster leaf %N July	-	7ab	X			
cluster leaf %K July	-	7ab	o			
twig leaf %N Aug.	-	7c-f	X			standardisation of vigour
twig leaf %P Aug.	-	7c-f				complication due to antagonistic uptake
twig leaf %K Aug.	-	7c-f	o			
twig leaf %Mg Aug.	-	7c-f	x			
twig leaf %Ca Aug.	-	7c-f				standardisation of vigour
flower bud %N March	-	8	x			method needs interpretation
flower bud %P March	-	8				method needs interpretation
flower bud %K March	-	8				method needs interpretation
Fruit						
ripening rate	-	9				control this when only one harvest date
weight	-	10	X			standardisation of bearing
size	6.1	10	X			standardisation of bearing
shape	6.3	-		x		
ground colour	6.2	10		X		
% blush	6.3	10		X		
blush colour red-purple	6.3	-		X		
shine	6.3	10		X		
number of seeds	-	11		x		standardisation of vigour
firmness at harvest	7.1	11	X			standardisation of vigour and bearing
starch reserve	-	-	x			
decrease in starch	7.2	11		x		standardisation of starch reserve
sugar (maximum high)	7.3	11	x			standardisation of bearing and growth
increase in sugar	7.3	11		x		
malic acid harvest	7.4	11	x			
Streif index at harvest	7.5	11		o?		too complex, we prefer components
technical quality index	7.6	-			o?	too complex, we prefer components
% dry matter	8	12	o?			
N	8	12	X			
P	8	12		?		
K	8	12	x			
Mg	8	12	x			
Ca	8	12	-	-	-	standardisation of bearing, vigour and no. of seeds (not in these studies)
free amino acids	9	13	X			
protein	9	13	x			
% protein	9	13		x	x?	
total phenols in skin	10.2	-		x		standardised for ripening
total phenols in flesh	10.2	14		o?	o?	standardised for vigour

Parameter	§ apple study 1	CD-ROM apple study 2	growth	differen-tiation	inte-gration	conditions
vitamin C	10.1	14	o?		o?	method used is not precise for low levels in Elstar
growth in CC-crystall.	13	16	x			
differentiation CC-crystall.	13	16		o		
integration in CC-crystall.	13	16			o?	
capillary rising picture	14	-	-	-	-	
Meluna initial value	15.1	17	x			
Meluna hyperbolicity	15.1	17		x / -	-	
Kwalis R40w	15.2	18	x			
Kwalis R40Y / B	15.2	18		o		
Kwalis ChiE / H50R	15.2	18			o	
Kwalis fruit typicality	15.2	-			o	
pH	16	19	o? / -			
redox pot. Eh	16	19		o? / -		method needs more validation
electrical resistance R	16	19		-		
dissipation P	16	19		o? / -		method needs more validation
dissipation Dp	-	19		-	-	method needs more validation
self-disintegration	11	-			-	method needs more validation
self-maintenance	11	-			-	method needs more validation
Botrytis after inoculation	-	22	o			method needs more validation
Bovis	17	-			o	method needs more validation
fruit taste						
sourness	12	15	x			
sweetness	12	15	x / -			standardisation of bearing and growth
crispness	12	15	X			
juiciness	12	15	-			
rawness	12	15		x		
mealiness	12	15		X		
aroma	12	15		X	X	depending on limiting factor: ripening or carbohydrates
astringent skin	12	15		-		
all odours	-	15		-	-	
all flavours	-	15		-	-	
all texture	-	15	o			
overall taste	12	15			X	
Fruit after storage						
shelf life (=firmness, Brix, acidity after 5+10 days)	-	20			-	
shrinking skin	-	20			-	
fruit rot	-	21bc	x?		x	
storage scab	-	21a	o			indication of humidity by vigour
storage scab	-	-				standardisation of microclimate (not in this study)

7.2 Comments on specific parameters

Tree vigour

Tree vigour and termination of growth are key properties for the fruit grower. On the one hand, the grower of full-grown trees needs leaf and twig growth for photosynthesis, but on the other hand vegetative growth competes with fruit growth. So the grower likes to see some vegetative growth early in the season, and when enough leaves have been formed, termination of twig growth in July and thereafter all assimilates are only for fruits. Termination of twig growth in July also gives the best opportunity for increases in fruit size and firmness (growth) and fruit ripening (differentiation).
Tree vigour had a moderate negative correlation with fruit firmness (R= -0.79; n=24), fruit blush (R= -0.54; n=24) and overall fruit taste (R= -0.68; n=12). This confirms the common knowledge in apple growing that a timely termination of vegetative growth is a key factor for good apple quality.

Autumn leaf colouring

Just as ripening rate can differ due to the treatments, autumn leaf colouring speed may also differ. In our earlier experiments in this orchard more fertilisation and / or greater vigour led to a delay in colouring and less colour, so less differentiation. Because of the storm in October 2002 in which salty sea spray was blown over the orchard, the leaves were dried brown before a normal autumn colouring process could happen, so we have no results.

Leaf analysis

Leaf analysis gives information about nutrient uptake by the roots and transport to the leaves. In early summer (beginning of July) samples were taken from the cluster leaves, the leaves that feed the fruit of the same year. In late summer (August) samples were taken from shoot leaves which provide the reserves for next year's flower buds. Leaf analysis is a sensitive instrument to check homogeneity of soil and tree and therefore we took a sample twice a year in every plot.
We found little correlation between soil minerals content and leaf minerals content. This is common knowledge. We did find high correlations between leaf minerals content and fruit minerals content for nitrogen (July: R=0.97; Aug: R=0.89; n=24), but not for the other minerals.
The leaf analyses of July correlated better with most fruit properties in the same year, and with flower bud analysis and balance in the next year. The leaf analysis of August correlated better with properties relating to growth such as tree vigour, leaf quality and fruit firmness.

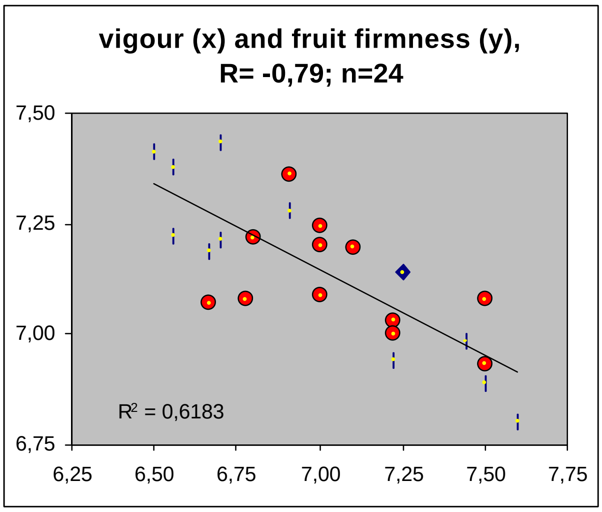
Flower bud analysis

Analyses of mineral content of flower buds in late winter were an experimental parameter which we did not know exactly how to interpret. The analysis technique is an existing one also used for leaves. We wanted to find a measure for the reserve substances in the flower bud to predict fruit set for practise. Bud reserves are a result of the process of storing amino acids and carbohydrates transported from the ripening autumn leaf to the buds before leaves fall. Flower buds flower and set fruit in the spring using these reserves, and hardly require any nutrient uptake from the soil (Friedrich and Fisher, 2000). We expected to find a relationship between total N in the flower bud and the total reserve substances and the fruit set, but this was not found.
In this study we used an orchard with nitrogen as a limiting factor and with sufficient and similar differentiation factors. So, we find a strong response by fertilisation on tree flowering; under these conditions it is a growth parameter.
In this study, a sample of 40 standardised flower buds was sufficient to allow interpretation of the results. The results of flower bud analyses were in line with leaf analysis, flowering scores and bearing, but did not correlate strongly.

Fruit firmness

To obtain sufficient firmness in fruits, a tree needs warmth, water, nutrients and moderately high bearing in the 6 weeks after bloom (Friedrich and Fischer, 2000). These are all growing factors, so at first sight we can consider firmness as a growth parameter.
From the first apple study and the literature, it is known that trees with high bearing get less firm fruits. In this second study, fruit from trees with similar bearing and increasing vigour decreased in firmness. This is an example to show how important it is to consider which parts (organs) of the tree should grow (see point 5 in the

improvements of the quality concept in §3.3). Fruits will lose firmness in the competition with twig and / or fruit growth. When twig growth and bearing are limited by management, and so do not compete, fruits can get firmer. Thus firmness can be considered as a growth parameter only on condition that it is not competing with twig growth and number of fruits.
In the first apple study (with similar bearing and growth) we saw that a later picking date resulted in decreased firmness and increased aromatic taste. So, under these conditions firmness is an (opposite) differentiation parameter.
The challenge to the fruit grower is to obtain firmness by moderating vegetative growth which allows relatively late harvesting and yields both properties: firmness and aroma! This is an example of what is meant in table 1a with 'growing phase optimum proportion between growth and differentiation'.



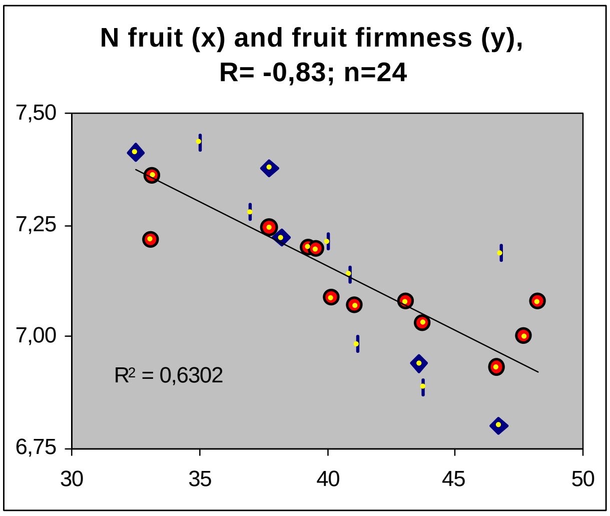
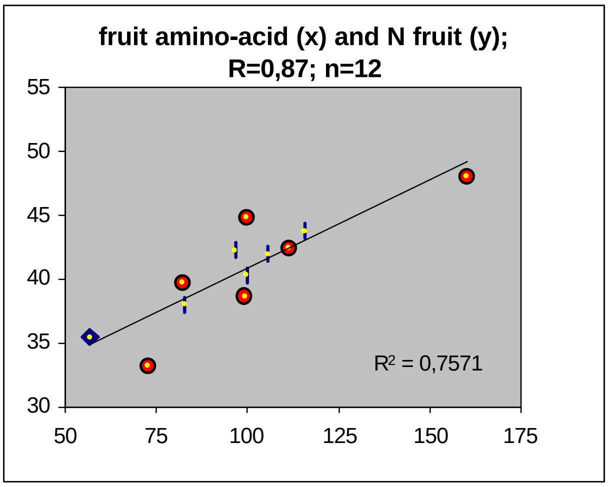


Figure 36: Correlations between vigour and firmness
Figure 37: Correlations between nitrogen in fruit and firmness

Figure 38: Correlations between free amino acids and nitrogen in fruit



'Physiological amino acid status' or 'protein ratio'
Schuphan (1976) assessed the quality of agricultural crops by measuring pure protein in relation to crude protein (Kjeldahl-N). In this study a similar parameter was chosen with the following consideration: the plant takes up nitrogen as nitrate and / or ammonium and uses it to make amino acids and then proteins. Proteins in apple are present mainly as enzymes. This process will continue when all growth factors are optimum (supply of water, light intensity, temperature, minor nutrients, etc). If growth stagnates, protein synthesis is inhibited and free amino acids accumulate. This also happens when excessive nitrate or ammonium is available. Amino acids and protein synthesis is dependent on a high energy supply in the form of carbohydrates. The proportion of protein and free amino acid expresses the physiological state of the plant and is also called 'physiological amino acid status'. High protein content indicates that mass building is nearly finished and that carbon supply and nitrogen uptake are in balance. High free amino acids content compared to pure protein content indicates unbalanced growth with an excess of nitrogen which can lead to undesirable nitrite formation or susceptibility to pests and diseases and loss of storage quality (Trophobiose theory of Chaboussou, 1987). For this view, we use 'protein ratio' as an indication for nearly finished and species typical growth, also for a crop as apple which has a low protein content.
We found high correlations for amino acids and protein content with many generally accepted growth parameters

(tree vigour, nitrogen in leaves, leaf quality, fruit weight). We can thus regard amino acids and protein content as growth indicators. For protein ratio, we found a moderate correlation with inverse growth parameters. In this study we cannot discriminate between inverse growth parameter or integration parameter.
For a product as apple with less protein content, the free amino acid content does not give more information than the total nitrogen content. The last is much cheaper.

Phenols in fruit

Phenols (all phenolic compounds) play a role in crop resistance and human health. This theme is a popular one in scientific publications today (Chaboussou, 1987; Mayr et al., 1995a,b,c, 1997; Herman, 1999; Hollman, 2001, Hagel, 2000ab; Nicholson et al., 1992; Fischer, 2003; Asami et al., 2003, Mayr et al., 1995a,b,c, 1997; Stout, Brovont and Duffey 1998; Rührmann et al., 2002; Nørbæk et al., 2003; Awad, 2001). As regards these components, we do not assume that the absolute content is the most important for health, i.e. we do not think that that for every food product 'a higher phenol content makes a healthier product'. We try to explain the relative amount as a result of life processes.

When growth of other organs is strong, this growth competes for carbohydrates; when there is any growth inhibition, there are fewer carbohydrates for building phenolic compounds (Herms and Mattson, 1992). In this study we found total phenols to be an inverse growth parameter, explained by competition for carbohydrates in line with this theory (fig. 25).

We expect that the different groups of phenols play a different part in this story; this needs to be studied more closely. The phenols (mainly anthocyan) in the fruit skin will increase with redder blush (see apple study 2001) and so phenols in the skin indicate ripeness (differentiation). On the other hand, the phenols in fruit flesh decrease during ripening and make the fruit tastier and more susceptible to diseases.

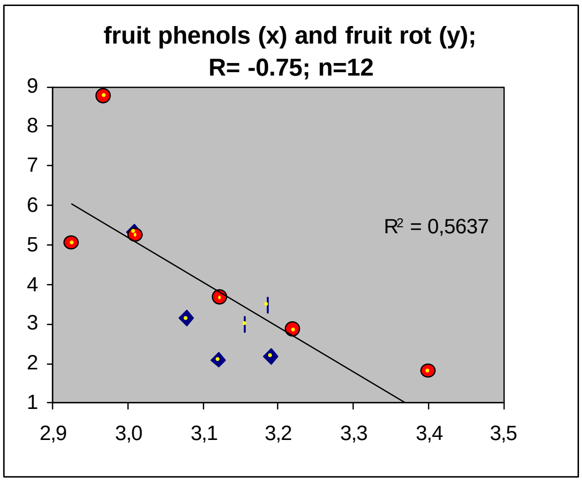


Figure 39: Correlations between phenols and fruit rot after storage.

We found a moderate correlation with rot resistance (fig. 39). If the phenolic content is above ca. 3.1 mg / g dw. fruit rot after storage is lower than 4%.

Taste

Just after harvest two different panels tasted apples, in Fulda and in Järna.

In Fulda the relevant sensory attributes for Elstar were:

10 x odour properties	10 x flavour properties	11x texture properties
cider, fresh grass, orange, citrus, banana, pear odour, earthy, nutty, wax candle, off-flavour / odour,	tart, sweet, pear flavour, cooked, woody, tart aftertaste, sweet aftertaste, bitter aftertaste, earthy aftertaste, off-flavour taste	surface, firmness, cracking, astringent, prickly, mealy, thickness, fibrous, refreshing, blunt, scratching
For the underlined attributes we found a 95% significant difference in one or more samples in this experiment.		

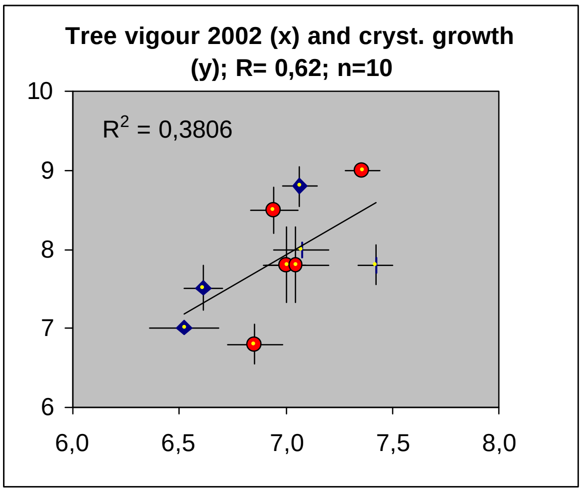
Despite the enormous effort of tasting a sample 50 times after ISO-standards, we found few significant differences. The differences in taste between the samples seem small and the differences between individual people and individual apples appear to be quite big. The poor quality of some apples in the sample from plots treated with 120 kgN without biodynamic field preparations was striking. We only saw interpretable differences in tartness (as a growth parameter), but so did a much cheaper analysis of acid.

The type of characterisation of the Järna taste group is very interesting for our quality concept. The chosen characterisation as 'best taste' seems to be a sum of integration processes (apple typical aroma, integrated sweet / tart, experience of light, roundness, etc), but we cannot prove this in this study. Also, the sample should be larger for more certainty.

Copper chloride crystallisation or 'biocrystallisation'

The copper chloride crystallisation method (CC-crystallisation or Biocrystallisation in future) was developed from the view that living organisms do not just consist of substances, but have 'living, architectural, structuring forces' which direct and organise. These structuring forces direct the form and function of the organism during the development of the product and are called 'life processes' in the Inner Quality Concept.
After evaporating water, the solids crystallise over a period of several hours and the pattern of the crystals is subsequently examined. The pictures were interpreted for growth, differentiation and integration. Growth is based on aspects like 'dense of radial formations', 'fullness with side needles' and 'degree of perradiation'. Differentiation is based on aspects like 'clear stems formed' and 'regularity of ramifications'. Integration is based on aspects like 'centre-coordination' and the 'degree in which the different form-elements in the picture have an organic connection with each other'.

The CC-crystallisation has a special meaning among the other parameters because we expected that using the pictures we could distinguish growth, differentiation and integration aspects. Therefore this parameter fits very well in the quality concept. The pictures demonstrate well how growth in trees in the orchard is replicated as growth in CC-crystallisation pictures of harvested fruit (fig. 40)



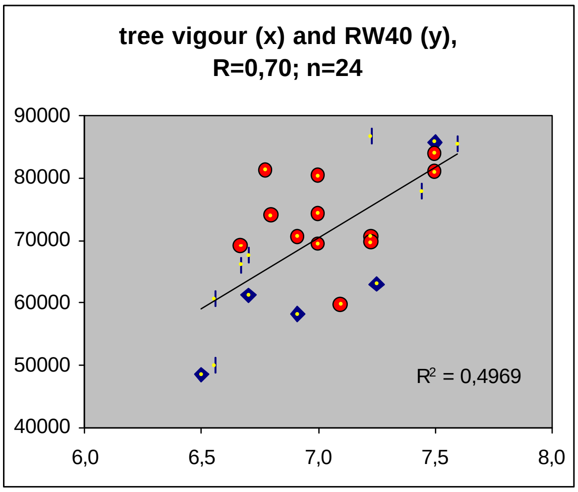


Figure 40: Correlation between growth score in CC-crystallisation and tree vigour (round dots with biodynamic preparations and square dots without).
Figure 41: Correlation between growth score in spectral range luminescence (R40W) and tree vigour.

Delayed luminescence of fruit

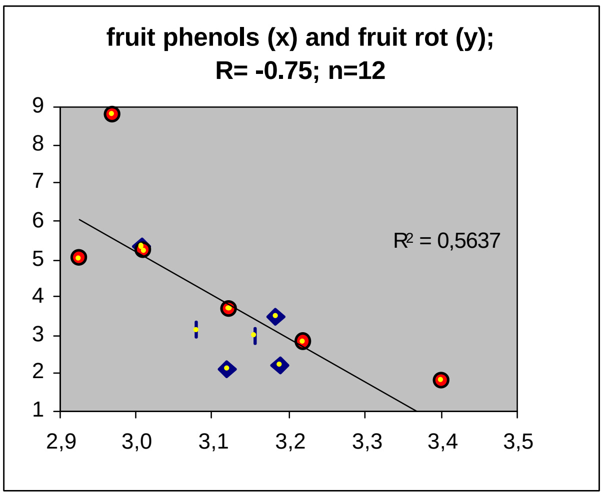
Plants in darkness emit a permanent and extremely low radiation of light (Ruth, 1976; Popp, 1979; Colli, 1954; Günther, 1983; Neurohr, 1992). Emission becomes stronger when preceeded by illumination (called induced emission or delayed luminescence). The intensity of the induced emission decreases and, after some time, the low permanent emission does likewise. The transition time depends on the sample material and varies from a few seconds to some days. Popp developed the 'bio-photon' analysis after illumination of biological samples without clear differences between induced and permanent emission.
Meluna Bio-photon Research uses the Popp method to measure luminescence after illumination with white light and Kwalis developed a different method with illumination with various colours (spectral range luminescence). Both methods were used in this project and are described in more detail on the CD-ROM 17a and 18c. The differences in the methods are summarised below:

Table 42: Differences between the two methods of delayed luminescence or fluorescence excitation spectroscopy and the hypothesis about relation to growth, differentiation and integration.

	Meluna: white light luminescence	Kwalis: spectral range luminescence
measured part of the apple	2 disks of inside of apple from both the blush and the ground colour side (2x)	whole fruit with the skin both the blush and the ground colour side (2x)
repetitions	12 apples	12 apples
colour of excited light	white	8 colours of the visible light spectrum
duration of measuring luminescence	3 to 200 sec	1 to 50 sec.
presented values	• initial value = emission after 4 seconds (growth?) • hyperbolicity = deviation of a hyperbolic curve (differentiation or integration?)	• R40W = mean emission between 30 and 50 seconds (growth?) • R40Y / B = % yellow / blue emission (differentiation?) • ChiE / H50R = hyperbolicity = deviation of a hyperbolic curve following red excitation (differentiation or integration?)

White light luminescence by Meluna
The previous study had given some evidence that the initial value after 4 seconds is a growth parameter and that hyperbolicity is a differentiation or integration parameter. In this study we could only see a tendency for initial value to act as growth parameter.

Spectral range luminescence by Kwalis
The spectral spectral range luminescence is an appropriate parameter for the Inner Quality Concept. Spectral range luminescence is assumed to include all three aspects of the concept in several combinations of measurements.
R40W behaved as growth parameter in the fertilisation series (fig. 29) and correlated with many growth parameters in the orchard and in fruits (example in fig. 41). So this strongly supports the Kwalis hypothesis that R40W can be considered a growth parameter.
R40Y / B behaved as differentiation parameter in the fertilisation series and correlated with fruit phenols (also a differentiation parameter). So this supports the Kwalis hypothesis that R40Y / B can be considered a differentiation parameter.
Parameter ChiE / H50R showed the highest value in the moderate fertilisation series (80 kgN, CD-ROM 18c), as expected of an integration parameter. Because we did not have a good reference series for integration, the hypothesis that ChiE / H50R is an integration parameter cannot be proved now.
For luminescence the sampling of apples has to be strongly standardised for light exposure.



Storage and shelf life
Maintaining firmness and acid after storage and after storage and shelf life is of great importance for commercial growers and easy to measure. We expected maintenance to be an integration aspect, but we could not confirm this in this study.

Figure 43: Correlation between phenol content and fruit rot

Fruit rot
Except for fruit rot, the infection level of pests and diseases was low and differences were not significant. Fruit rot after storage is moderately positively correlated with nitrogen content in fruit (R = 0.60; n=24) and leaf (R=0.52; n=24) and had a strong negative correlation with calcium content in fruit (R = -

0.91; n=24) and phenol content (R=0,75; n=24, fig 43). When calcium content > 4.3 mg or nitrogen content < 40 mg in 100 gram fresh fruit, then fruit rot after storage was less than 4% in this orchard.

Botrytis-resistance test and the self-disintegration test

For an apple, resistance to fruit rot is developed at different levels: first, an undamaged skin protects the fruit against infection and second, after infection occurs, fruit flesh can be more or less resistant to the fruit rot infection. We designed a new *Botrytis*-resistance test to test only the second property, which is thought to be an integration property. The test is an improved version of the self-disintegration test used in the previous apple study. The problem with the self-disintegration test was the insufficient repeatability by unknown and varying infection circumstances. Therefore, we now inoculated with a standard *Botrytis* spore suspension and measured the diameter of the rotten spot after breeding in a climatic chamber. This test was carried out to get a rough idea of the potential of the new test in its larger validation programme (Zanen en Bloksma, 2004).

Botrytis spot diameter is positively correlated with many growth parameters, so *Botrytis* resistance is negatively correlated with growth.
We found a moderate correlation between *Botrytis* resistance and % natural fruit rot after storage (fig. 44), so this test provides good prospects for a predictive test for storage losses by fruit rot.

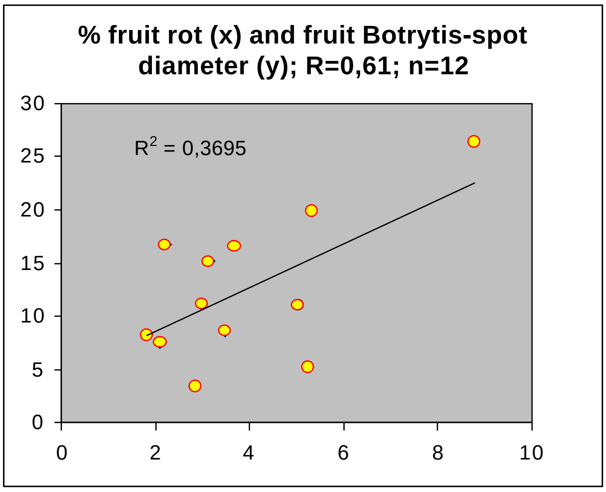


Figure 44: Correlation between the diameter of the rotten spot after Botrytis inoculation and % natural fruit rot.

Cluster analysis

We performed a non-linear multivariate analysis (NPCA; Gifi, 1990) on the experimental data to see whether the parameters believed to belong to growth, differentiation and integration processes arise as three clusters in order to check our three hypothetical processes. This was not the case. This does not surprise us because only the nitrogen series leads to clear differences in growth parameters. The three experimental series are not sufficient to test the whole concept. This needs to be repeated in an experiment with adequate measures for all three aspects, growth, differentiation and integration.

8 Final conclusions and prospects

The Inner Quality Concept

The Inner Quality Concept for food is an improvement of the Vital Quality Concept (2001). The first concept already had the benefit of being suitable for organic growers, consumers and holistic health workers, because it is related to life processes. It connects the growing crop / animal with the product in the shop and it also has the potential to connect the food product with human health. The life processes of growth and differentiation provide this connection and build the framework for the holistic concept. This concept enables us to interpret the results of several independent quality measurements in terms of which management measures may be used to regulate the crop and hopefully in the future also in terms of regulation of health. We are not aware of any other quality concept with this holistic potential.

The Inner Quality Concept has some improvements compared to the Vital Quality Concept in 2001: we avoided some confusing terms (vitality, structure, coherence for all crops). We did not consider storability and plant hormones because these are both too complicated to classify on one dimension. We described the growing and differentiating processes separately for the several organs (twigs, leaves, fruits, flower buds) and classified them in the season. We moved the parameter high content of secondary compounds from differentiation to integration, because the precursors are products of primary metabolism and the conversion is a differentiation process and this combination is in effect integration.

The apple-2 experiment

After the first apple experiment with series varying growth and differentiation, we want to focus in the second apple experiment on integration. As explained in §3 we assume two aspects of integration: balance and interaction of the life processes growth and differentiation. In this second study dealing with fertilisation levels we tried to realise various proportions: a line from too little via the optimum to too much growth in relation to differentiation. And over these fertilisation series we vary biodynamic field preparations as a possible interaction factor. Compost was added to study a different time dynamic in nitrogen release, and it may also increase integration.

In §5 we present our expectations and the results of the parameters in relation to the three experimental factors: fertilisation level, compost compared to commercial fertilisers and biodynamic field preparations. At different fertilisation levels we saw a shift in the balance of growth and differentiation and found an optimum level between the extremes. Most other management factors were sufficiently standardised to avoid undesired influences. Field effects did have a confounding influence.
We did not achieve greater integration in the way we expected. We did not see much difference in resistance to pests and diseases, shelf life, or taste. These properties were assumed to be Golden Standard parameters for integration. Because some pesticides were used against key pests and because the variety Elstar usually has a good flavour, these parameters did not show enough differences to use them as a generally accepted standard. Also, we didn't see clear differences in experimental parameters for integration in the series with compost or biodynamic field preparations. Consequently in the second apple study we have learned that the presumed integration in figure 1 is not easy to achieve in an experiment.

Answers to questions from practice:

1. In this orchard with a nitrogen-retaining soil the optimum fertilisation level for consistent production of tasty and storable fruits is about 100 kgN / ha applied on the tree strip. The orchard management includes careful fruit thinning to about 110 fruits / tree around six weeks after bloom, irrigation during drought, pest and weed control and night frost prevention. Under these conditions a yield of 40 tonnes of high quality apples per hectare is possible, which is much higher than the average Dutch organic fruit grower achieves.
2. For consistent production and quality we do not see much difference between 100 kgN / ha from composted cow manure and from the combination of two commercial fertilisers (Maltaflor and chicken manure pellets) when used over many years. Compost produced a delay in the mineralisation and also a decrease in many growth properties compared with the commercial fertilisers. In the first year this is undesirable, but after some years this is made up for in the next year and conditions stabilise. The Järna panel found a tendency towards better taste in the composted fields. Compost has benefits for the soil: more soil life resulting in faster

decomposition of leaves. In practice a combination of compost and commercial fertilisers will provide for good soil life, less labour and nitrogen release over time.
3. The experimental design was not suitable to show the effects of two years of non-use of biodynamic field preparations in the two untreated blocks in the orchard. We cannot conclude that biodynamic field preparations have an effect. It is possible that the effect of treatment in the past (before this experiment) or use in the neighbouring block (10 meter buffer) was still influencing the untreated blocks. We do not know the radius of influence of these biodynamic field preparations. There were several differences that could be explained by both biodynamic field preparations and by soil factors.

Three of the five hypotheses on the development of the quality concept were confirmed:
1. Increasing fertilisation leads to an increase in many growth properties and a decrease in differentiation properties: trees with more twig growth and later termination of growth resulting in more diseases, darker green and bigger leaves, higher nitrogen contents in flower buds, leaves and fruits. With more fertilisation apples were bigger, less firm, had fewer phenols, were slightly more acid and had more fruit rot and less blush. It was not clear in every case whether this was related to inhibition of growth or to differentiation.
2. Compost indeed showed a delay in nitrogen release in compared to quick-releasing commercial fertilisers resulting in a decrease in many growth-related properties. After two years this growth delay disappeared.
3. The application of biodynamic field preparations did not show integration in the way we expected, except for the possible faster leaf decomposition on the soil.
4. We found many growth parameters in the harvested fruits corresponding with growth parameters in the growing crop. We were also able to correlate several experimental parameters with Golden Standard growth parameters.
5. Because of the absence of good measures for integration in this experiment we were not able to check whether the three aspects of the quality concept, growth, differentiation and integration, arise from the experimental data as three distinct parameter clusters using the statistical method of principal component cluster analysis.

We came to a further understanding of experimental parameters:
1. In copper chloride crystallisation by LBI and in spectral range luminescence by Kwalis the assumed ‘growth-scores’ indeed correlated with Golden Standard growth parameters of growing crop and fruit. For the ‘differentiation-scores’ of both methods the tendency was in line with the expectation. So these two methods provide us with promising parameters for growth and differentiation. The study was not suitable for the evaluation of the ‘integration scores’.
2. The electro-chemical parameters are not sufficiently standardised or not sufficiently sensitive for the differences in the apples in this study. The same conclusion can be drawn for the delayed luminescence by Meluna. However both parameters seemed promising in the first apple study.
3. The soil chromas and soil life counts were carried out for exploratory purposes only, but there were insufficient samples for a real evaluation. After this orientation they look promising for measuring the effects of compost and commercial fertilisers on soil.
4. The Botrytis rot-resistance test is a further development of the self-decomposition test by LBI under more controlled conditions. Including this parameter in this study was part of the validation route for this new parameter. We found correlations with parameters for over-fertilisation.
5. We were able to interpret the commonly used parameters for fruit quality in terms of life processes. For example: a high level of free amino acids or a low protein ratio in apples indicates the fruit is still growing and a high protein ratio indicates that the product is already finished. A high concentration of phenols in fruit flesh indicates differentiation.

Recommendations for further research on the Inner Quality Concept:
1. The physiological processes underlying integration (balance and interaction between growth and differentiation) and the management measures which can influence them need to be studied in greater detail in order to design an experimental set-up with relevant management factors for integration.
2. To validate the quality concept, a less complex crop than apple would make for easier study. In any case preference should be given to an annual crop without many different organs. The benefit of apple is the link with practice: apple growers already think in terms of growth and differentiation. The presence of pests and diseases after plant youth is desirable, because resistance to pests and diseases is a strong parameter for integration.

3. This quality concept should be reviewed in the context of other quality concepts for general agricultural products.
4. Research on the link with human and animal health.

9 Literature

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10 Annexes

10.1 Biodynamic preparations application schedule

General policy of Orchard ter Linde in working with the biodynamic field preparations
Below some guidelines to follow if practical and affordable:

1. Compost preparations at the start of the season to harmonise soil processes and life forces.
2. Extra valerian preparation (one of the compost preparations) when the trees need some warmth.
3. Extra oak preparation (one of the compost preparations) to contract when trees prepare for winter rest.
4. Horn-manure field preparation to support roots, soil life and decomposition, spayed on the soil.
5. Horn-silica field preparation at different times on the tree and soil with different accents:
    - Morning-silica in periods of growth to support assimilation: sprouting of flower cluster, pollination, unfolding leaves, twig growth.
    - Afternoon-silica in periods of differentiation: flower bud initiation, cessation of twig growth, fruit ripening, leaf ripening and withdrawal of nutrients from reserve, formation of cork at the leaf scars. At this time of day there is some danger of burning.
    - Noon-silica in periods of all processes together. At this time of day there is some danger of burning.

date	time of stirring	preparation	remarks always together with visualisation of limits of the experiment.
9-5-2001		horn-manure	
10-5-2001		horn-manure	
5-6-2001		horn-manure	
10-7-2001		horn-silica	
23-7-2001		horn-silica	
20-8-2001		horn-silica	
29-10-2001		horn-manure	+ compost preparation 'oak'
30-10-2001		horn-manure	+ compost preparation 'oak'
21-3-2002	14.45-15.45	5 compost + valerian last 10 min.	Trees in 'green bud', first spring feeling, clouded. Compost preparations to stimulate integration of soil processes. Compost preparations applied without compost to apply the compost preps also in block A2 and B2 in plots with commercial fertilisers.
15-4-2002	18.30-19.30	horn-manure + valerian last 10 minutes.	Tree stage of 'balloon', before flowering, clouded. To stimulate root activity in this dry period and valerian for frost prevention.
7-5-2002	7.30-8.30	horn-silica	Tree stage of 'petal fall', just after flowering. Hazy sunrise. Spray early in the day to avoid burning. To stimulate flower bud differentiation for the next season.
23-5-2002	7.30-8.30	horn-silica	Tree stage of young fruitlets, clouded / sunny. Morning spray to stimulate the assimilation.
14-6-2002	10.30-11.30	horn-silica	Tree stage of growing shoots, hazy clouded, warm (20°C) after cold and wet weather. Morning spray to stimulate assimilation.
22-7-2002	14.17-15.17	horn-silica	Shoots still growing, alternating bright and hazy. Afternoon spray to stimulate cessation of shoot growth.
			August: too bright and sunny for application of horn-silica.
5-9-2002	15.30-16.30	horn-silica	3 weeks before harvest, after bright and sunny weather now the first signs of rain are noticed in the air. Afternoon spray to promote fruit ripening.
30-10-2002	13.30-14.15	horn-silica	Calm autumn weather after strong storm 27-10-02 which forced leaf fall. To stimulate recovery after storm
			November leaf fall: horn-manure planned but not applied
31-3-2003	15.30-16.30	horn-manure +6 compost + valerian last 10 mins.	Bright sunny, cold wind. Trees near green-tip stage. To stimulate the growth and also to apply compost preps to trials with commercial fertilisers.

10.2 Overview of parameters, instruments and sampling

	properties	parameter	instrument	unit	date of sample *analysis*	sub-sam ple[1)]	per plot	per 2 plots	per 4 plots	per tree	per fruit	per fruit box	repli cati-ons	Level [2)]	annex
soil	organic matter			% dry weight	7-11-02	A		20 samples (0-30 cm)					1	cont	1
soil	acidity	acidity in KCl	pH-meter	(pH)	7-11-02	A		20 samples (0-30cm)					1	cont	1
soil	available K			mg K2O / 100g humid	7-11-02	A		20 samples (0-30 cm)					1	cont	1
soil	reserve K		flame emission in1%HCl	mg K2O / 100g humid	7-11-02	A		20 samples (0-30 cm)					1	cont	1
soil	available P	Pw-count		mg P2O5 / liter	7-11-02	A		20 samples (0-30 cm)					1	cont	1
soil	reserve P		spectroscopy in 1%HCl	mg P2O5 / kg humid	7-11-02	A		20 samples (0-30 cm)					1	cont	1
soil	respiration	CO2-production	Incubation in 7 days	mg CO2 / 100 g humid	7-11-02	A		20 samples (0-30 cm)					1	cont	1
soil	integration	balance between earth, water, air,	chroma-tography	many scores	7-11-02	A		20 samples (0-30 cm)					1	pic / cat	2
soil	available N	NO3- + NH4+		ppm	7-11-02	B	10 samples (0-30 cm)						1	cont	1
soil	leaf decomposition	speed of leaf disappearence	228-cell mesh nets over leaves	%cells with leaf material since first date	6-12-02 12-2-03 7-3-03 1-4-03	C	2 x 0,5 m^2 mesh						2	cont	3
soil	weed growth	% soil covered with weeds	estimate	% under the gause	1-4-03	C	2 x 0,5 m^2 mesh						2	cont	3
soil	micro soil life	total bacteria	count under	# per 1 gram	30-4-03	D	40						1	cont.	2

	properties	parameter	instrument	unit	date of sample *analysis*	sub-sample[1)]	per plot	per 2 plots	per 4 plots	per tree	per fruit	per fruit box	replications	Level [2)]	annex
			microscope	of soil			samples (0-15cm) only plot 0,4,6.								
soil	micro soil life	total fungi	count under microscope	# per 1 gram of soil	30-4-03	D	40 samples (0-15cm) only plot 0,4,6.						1	cont.	2
soil	micro soil life	fungi / bacteria	calculation		30-4-03	D	40 samples (0-15cm) only plot 0,4,6.						1	cont.	2
manure	mineral content	N, P, K,	as soil	weight % in fresh matter	Apr.'02	E				per manure			1	cont	4
manure	organic matter	organic matter	muffle furnace	%	Apr.'02	E							1	cont	4
manure	ripeness, balance		chromatography	-	7-11-02	E							1	pic / cat.	4
tree bud	mineral content flower buds	N, P, K	spectrophotometry (N, P) and flame-photometry (K, Mg, Ca)	% / dm	8-3-02	F		80 buds					1	cont	8a
tree bud	mineral content flower buds	idem	idem	idem	27-3-03	G	40 buds						1	cont	8b
tree	flowering capacity	flowering-figure for % cluster is cluster with flower	estimate	scale 0-10 (10=100% fl.cluster)	25-4-02	H	x			10			10	disc	5
tree	flowering capacity	idem	idem	idem	1-5-03	I	x			10			10	disc	5
tree	mineral content	N, P, K,	see buds	% / dm	4-7-02	J	50						1	cont	7a

	properties	parameter	instrument	unit	date of sample *analysis*	sub-sample[1)]	per plot	per 2 plots	per 4 plots	per tree	per fruit	per fruit box	replications	Level [2)]	annex
leaf	cluster leaves						leaves								
tree leaf	mineral content shoot leaves	N, P, K, Mg, Ca	see buds	% / dm	24-8-02	K	50 leaves						1	cont	7b
tree	rosy apple aphid	tree with or without aphid damage	count	scale 0=no and 1=yes aphid	15-8-02	-	x			10			10	bi	5
tree	leaf series	twig length + internodia-distance + leaf area +regularity	centimeter estimate	illustrated as 'leaf series'	15-8-02	L			1 representa-tive shoot				1	desc	6
tree	vigour	amount and length of shoots	subjective judgement	scale 0-10 (5=optimal)	15-8-02	-	x			10			10	disc	5
tree leaf	leaf quality	size and colour of leave	estimate	scale 0-10 (10=dark green and big leaves)	15-8-02	-	x			10			10	disc	5
tree	tree balance	combination of vitality and rest	subjective judgement	scale 0-10 (10=best)	15-8-02	-	x			10			10	disc	5
tree	bearing capacity		subjective judgement	scale 0-15 (10=optimal)	15-8-02	-	x			10			10	disc	5
tree twigs	growth termination	% closed twigs in top	estimate	% / all top twigs	15-8-02	-	x			10			1	cont	5
tree	fruit ripening speed	sugar, starch firmness Streif	Brix-meter lugol-test penetrometer calculation	degree scale kg / cm2 figure	2002: 15-8; 21-8; 30-8; 4-9; 10-9; 18-9.	 M N O P Q R		15 fruits; only plot: 1, 3, 5, 6.					1	cont	9
tree	autumn colouring	% yellow-red leaves per tree in autumn	vision, estimate	%	7-11-02	-	x			10				cont	5
fruit	glossy fruit skin (shine)	wax on the skin	vision	-	19-9-02	S	x					2 boxes	2	desc	10

	properties	parameter	instrument	unit	date of sample *analysis*	sub-sam ple[1)]	per plot	per 2 plots	per 4 plots	per tree	per fruit	per fruit box	repli cati-ons	Level [2)]	annex
fruit	red blush on skin	% surface red skin / total skin	vision	%		S	x					2 boxes	2	desc	10
fruit	russeting	% surface russe-ted / total skin	vision	%		S	x					2 boxes	2	desc	10
fruit	ground colour	green-yellow fruit skin	vision	-		S	x					2 boxes	2	desc	10
fruit	fruit weight	total weight / total amount per box	scales count	gram	after storage	T	x				x		1	cont	10
fruit	% rot after storage	sum of several types of fruit rot	count	% / all fruits	20-9-02 *3-1-03*	T	x				x		180	bi	21
fruit	wrinkled skin after storage (softness)	% wrinkled skin and soft tension	estimate feeling	% / all fruits	20-9-02 *3-1-03*	T	x				x		180	bi	21
fruit	% older scab after storage	% older scab after storage	count	% / all fruits	20-9-02 *3-1-03*	T		360 fruits only plots 1,5					1	bi	21
fruit	% storage scab after storage	% storage scab after storage	count	% / all fruits	20-9-02 *3-1-03*	T		360 fruits only plots 1,5					1	bi	21
fruit	% leaf roller after storage	% leaf roller after storage	count	% / all fruits	20-9-02 *3-1-03*	T		360 fruits only plots 1,5					1	bi	21
fruit	rot resistance test after storage	diameter brown spot by Botrytis	inoculation test	mm	20-9-02 *3-1-03*	U		x			20		40	cont	22
fruit	mineral content	N,P,K,Mg,Ca	see buds	% weight / dry weight	19-9-02	V	25						1	cont	12
fruit	dry matter	see above		% / fresh	19-9-02	V	25						1	cont	12
fruit	phenolic compounds	sum of phenolic compounds in flesh + skin	extraction and HPLC	mg / g dry	19-9-02	W		12 fruits					1	cont	14
fruit	vitamin C in fruit juice	vitamin C in fruit juice	titration	mg / 100 ml juice	19-9-02	AD		5 fruits					1	cont.	16
fruit	amino acids	sum of free amino acids in fruits	a.a. analyser	mg / 100 g fresh	19-9-02	X		10 fruits					1	cont	13
fruit	protein	crude protein	Kjeldahl	mg / 100 g	19-9-02	X		10 fruits					1	cont	13

	properties	parameter	instrument	unit	date of sample *analysis*	sub-sam ple[1)]	per plot	per 2 plots	per 4 plots	per tree	per fruit	per fruit box	repli cati-ons	Level [2)]	annex
				fresh											
fruit	protein proportion	protein-N / N in amino acid and in protein	calculation	-	19-9-02	X		10 fruits					1	cont	13
fruit	firmness	firmness	penetrometer	kg / cm2	19-9-02	Y	25						25	cont	11
fruit	sugar content juice	optical diss. substances in fruit juice	Brix-meter PPO	%	19-9-02	Y	25						1	cont	11
fruit	malid acid in juice	acid compounds of fruit juice	titration	g / liter	19-9-02	Y	25						1	cont	11
fruit	starch	disappearing starch in fruit	lugol test on half apples	scale 1-10 1=very ripe	19-9-02	Y	25						25	disc	11
fruit	ripening stage	Streif-index	calculation	-	19-9-02	Y	25						25	cont	11
fruit	number of seeds	# seeds / fruit	count	-	19-9-02	Y	25						25	disc	11
fruit	firmness after storage	firmness	penetrometer PPO	kg / cm2	20-9-02 *8-1-03* *13-1-03*	Z AA	25						25	cont	20
fruit	sugar content after storage	optical diss. substances in fruit juice	Brix-meter PPO	%	20-9-02 *8-1-03* *13-1-03*	Z AA	25						1	cont	20
fruit	malid acid in juice after storage	acid compounds of fruit juice	titration PPO	g / liter	20-9-02 *8-1-03* *13-1-03*	Z AA	25						1	cont	20
fruit	33 aspects of taste		taste panel Fulda	scale 0-10	19-9-02	AB	12						50	disc	15
fruit	integration aspects of taste		taste panel Järna	--	19-9-02	AC	5						5	desc	15
fruit	many CC-crystallisation-aspects LBI	see method description	CC-crystalli-sation, empathic observation		19-9-02	AD AE		5 fruits					2	disc	16
fruit	delayed luminescence Meluna	initial value 4sec of an apple disc	photon-meter	--	19-9-02	AF		12 fruits					12	cont.	17
fruit	delayed	hyperbolicity	photonmeter	--	19-9-02	AF		12 fruits					12	cont.	17

	properties	parameter	instrument	unit	date of sample *analysis*	sub-sam ple[1)]	per plot	per 2 plots	per 4 plots	per tree	per fruit	per fruit box	repli cati-ons	Level [2)]	annex
	luminescence Meluna	4 sec of an apple disc													
fruit	spectral range luminicence Kwalis	R40 / W of a whole apple	photon meter	--	19-9-02	AG		12					1	cont	18
fruit	spectral range luminicence Kwalis	R40 yellow / blue of a whole apple	photon meter	--	19-9-02	AG		12					1	cont	18
fruit	spectral range luminicence Kwalis	ChiE / H50 red of a whole apple	photon meter	--	19-9-02	AG		12					1	cont	18
fruit	acidity of fruit	H+ in fruit juice	pH-meter	--	19-9-02	AH		4x5					4	cont	19
fruit	redox potential	redox potential of juice	volt meter	mV	19-9-02	AH		4x5					4	cont	19
fruit	elec. resistance	electr. resistance of juice	resistance meter	ohm	19-9-02	AH		4x5					4	cont	19
fruit	P-value	P-value of juice	calculation	-	19-9-02	AH		4x5					4	cont	19
fruit	DP-value	DP-value of juice	calculation	-	19-9-02	AH		4x5					4	cont	19

1)= Parameters from equal sub-sample have the same character.
2)= levels of measurement: descriptive or pictural / binomial / categories / discrete or continue

10.3 Contents of the CD-ROM with extended results and comments

The CD-ROM includes all measurements in means, standard error of the mean (sem) and figures per field, pictures from picture developing methods and discussion of the several parameters.

1. **Soil 2002: mineral analysis and organic matter**
   1a: means of the soil analysis
   1b: means of soil nitrate
   1c: figures of soil analysis and nitrate per field
   1d: figures of soil analysis and nitrate per treatment
   1e: discussion of soil analysis

2. **Soil 2002: chroma and micro life**
   2a: soil chroma method and interpretation
   2b: pictures of soil chroma
   2c: means of soil chroma
   2d: figures-1 of soil chroma
   2e: figures-2 of soil chroma
   2f: discussion of soil chroma
   2g: means of soil micro life
   2h: figures of soil micro life
   2i: discussion of soil micro life

3. **Soil 2002-2003: weed cover and leaf decomposition**
   3a: means of weed cover and leaf decomposition
   3b: figures of weed cover and leaf decomposition
   3c: discussion of weed cover and leaf decomposition

4. **Manure: analysis and chroma**
   4a: pictures of manure chroma
   4b: manure content analysis and chroma interpretations

5. **Tree 2002 and 2003: crop observations**
   5a: means of flowering, vigour and bearing in 2002
   5b: means of termination, leaf quality and balance in 2002
   5c: figures of flowering, vigour, leaf quality, balance and termination in 2002
   5d: means of flowering, thinning, bearing, vigour, balance and leaf quality in 2003
   5e: figures of flowering, thinning, bearing, vigour, balance and leaf quality in 2003
   5f: discussion of crop observations

6. **Tree 2002: 'Leaf series'**
   6a: pictures of leaf series
   6b: discussion of leaf series

7. **Tree 2002 and 2003: leaf analysis**
   7a: means of leaf analysis July 2002: N, P, K
   7b: figures of leaf analysis July 2002: N, K
   7c: means of leaf analysis August 2002: N, P, K, Mg, Ca
   7d: figures of leaf analysis August 2002: N, P, K, Mg, Ca
   7e: means of leaf analysis August 2003: N, P, K, Mg, Ca
   7f: figures of leaf analysis August 2003: N, K, Ca
   7g: discussion of leaf analysis

8. **Tree 2002 and 2003: flower bud analysis**
   8a: means of flower bud analysis March 2002: N, P, K

8b: means of flower bud analysis March 2003: N, P, K
8c: figures of flower bud analysis March 2002 and 2003: N, P, K
8d: discussion of flower bud analysis

9. Tree 2002: ripening speed
9a: figures of firmness, Brix, starch of ripening fruits at the tree
9b: discussion of ripening speed

10. Fruit 2002: external properties
10a: means of fruit blush and weight
10b: figures of fruit blush and weight
10c: discussion of external fruit properties

11. Fruit 2002: internal fruit properties
11a: means of fruit firmness, number of seeds and starch
11b: means of malic acid, sugar and Streif-index
11c: figures of fruit firmness, number of seeds and starch
11d: figures of malic acid, sugar and Streif-index
11e: discussion of internal fruit properties

12. Fruit 2002: dry matter and mineral content
12a: means of fruit dry matter, N and P content
12b: means of fruit K, Mg and Ca content
12c: figures of fruit N, P, K, Ca content and dry matter
12d: discussion of dry matter and mineral content

13. Fruit 2002: free amino acids and protein
13a: means of free amino acids, protein and protein ratio
13b: figures of free amino acids, protein and protein ratio
13c: discussion of free amino acids, protein and protein ratio

14. Fruit 2002: phenols and vitamin C
14a: means of phenols and vitamin C
14b: figures of phenols
14c: figures of vitamin C
14d: discussion of phenols
14e: discussion of vitamin C

15. Fruit 2002: sensory properties
15a: means of all taste attributes from Fulda
15b: means of main attributes from Fulda
15c: figures of main attributes from Fulda
15d: method description sensory test Järna
15e: means of rank order overall taste Järna
15f: figures of rank order overall taste Järna
15g: discussion of sensory properties

16. Fruit 2002: copper chloride (=CC) crystallisation
16a: details about LBI-method of CC-crystallisation
16b: photo's of the pictures of CC-crystallisation
16c: means of scores in CC-crystallisation
16d: figures of scores in CC-crystallisation
16 e: discussion of CC-crystallisation

17. Fruit 2002: delayed luminescence by Meluna
17a: method description delayed luminescence by Meluna

17b: means of delayed luminescence by Meluna
17c: figures of delayed luminescence by Meluna
17d: discussion of delayed luminescence by Meluna

18. Fruit 2002: spectral range luminescence by Kwalis
18a: means of spectral range luminescence by Kwalis
18b: figures of spectral range luminescence by Kwalis
18c: discussion of spectral range luminescence by Kwalis

19. Fruit 2002: electro-chemical measurements
19a: means of electro-chemical measurements
19b: figures of electro-chemical measurements
19c: discussion of electro-chemical measurements
19d: electro-chemical parameters and their interpretation by Heilmann

20: Fruit 2002 storage and shelf life: change in firmness, sugar and acid
20a: means before storage and 5 and 10 days after storage
20b: figures before storage and 5 and 10 days after storage
20c: discussion of storage and shelf life

21. Tree and fruit 2002: pests and diseases
21a: means and figure of scab and leaf roller
21b: means of aphid and fruit rot
21c: figures of fruit rot
21d: discussion of pests and diseases

22. Fruit after storage 2002-2003: Botrytis-resistance
22a: means of Botrytis spot-diameter after inoculation
22b: figures of Botrytis spot-diameter after inoculation
22c: discussion of Botrytis-resistance

23. Field check for homogeneity by soil profiles
23a: Soil profiles
23b: Change in key parameters in the field

24. Parameters linear correlations
24a: parameters with n=10
24b: parameters with n=20

Photos:

3-033 fruit grower Heleen van Elsacker prepares the biodynamic field preparations
3-035 fruit grower Heleen van Elsacker applies the horn-silica field preparation
3-037 fruit grower Piet Korstanje applies the horn-manure field preparation
3-038 fruit grower Piet Korstanje applying composted cow manure in the orchard
3-039 flowering time in the orchard
3-041 orchard in summer time: mostly green by growing twigs and leaves
3-043 LBI worker Marleen Zanen harvests in the orchard
3-044 Maltaflor pellets
3-045 overview over the exterior quality: form above to below: block A1, B1, A2, B2 and from left to right hand side: 0, 40, 80, 120, 160, 100 compost in kgN / ha.
3-047 LBI worker Joke Bloksma does last check before sending
3-048 LBI worker Paul Doesburg sends boxes with apples to the various laboratories
3-027 LBI worker Paul Doesburg inoculates apples with spores for the Botrytis-resistance test
3-029 close-up of apples with fruit rot spot in Botrytis-resistance test
1-020 electro-chemical measurements by Hartmut Heilmann
1-024 spectral range luminescence by Kwalis

1-026	white light luminescence by Meluna
3-050	PPO worker Cees Westeweele measures firmness
4-180	crystallisation room, Louis Bolk Instituut
3-054	LBI workers Machteld Huber and Anna de Weerd evaluates CC-crystallisation pictures
4-165	taste panel group, Fulda
4-166	reference table for tasters, Fulda
4-167	taste cabins, Fulda
4-178	front cover report FQH-apple-2
4-181	soil profile drawing

Key to tables of individual parameters used on the CD-ROM and in §6:

The treatments on the horizontal axis are:
0 = unfertilised
40 = 40 kgN / ha from dried chicken manure and Maltaflor
80 = 80 kgN / ha from dried chicken manure and Maltaflor
120 = 120 kgN / ha from dried chicken manure and Maltaflor
160 = 160 kgN / ha from dried chicken manure and Maltaflor
100c = 100 kgN / ha from composted cow manure
yes = with biodynamic field preparations
no = without biodynamic field preparations
In the figures the standard errors of the means are included as lines in the bar.

Some graphics distinguish between replicated blocks:
A1-A2-B2-B1 is block field order, A1 is relatively poor
blocks A and B are replications and block 1 = without and 2 = with biodynamic field preparations for 2 years