Quality of Vegetables -

Comparison of open pollinating varieties and F1 hybrids Results from over twenty years with the image-creating methods.

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The use of F1 hybrids in vegetable cultivation has been the subject of controversial debate within the biodynamic movement for years.

Against this background, the German Biodynamic Research Centre (Forschungsring e.V.) was commissioned in 2022 to determine the state of knowledge about the intrinsic quality of vegetable varieties. By intrinsic quality, we meant the results of various holistic investigation methods, such as image-forming methods (especially copper chloride crystallisation and rising image), empathic food testing and formative forces research and image force research.

To this end, the available literature was reviewed, including unpublished reports. In addition, a number of people who had been involved in the comparison of F1 hybrids and seed-resistant varieties. A total of 16 experts were involved. Four people were interviewed using an interview guide developed for this purpose.

In the scientific literature, extended methods for quality investigation - beyond analyses - have been little represented to date. A few studies on method development, validation and cultivation system differences exist on image-creating methods. No publications were found in scientific journals on vegetable varieties that differ in their breeding method (open pollinating vs. F1 hybrid).

During the research it quickly became clear that most of the studies on this topic were carried out using the image-forming methods. The analysis therefore focusses on the results of these methods. It also emerged that the vast majority of the studies were available in the form of unpublished project reports from Kultursaat e.V.. These were based on the question of whether the association's own biodynamic new varieties represent a qualitative improvement on the varieties widely used in Demeter vegetable production - many of which are conventionally bred F1 hybrids. On this data basis, the present study is primarily a retrospective analysis of what was currently available to consumers at the time of the study, focussing on the comparison between open pollinating varieties and F1 hybrids. Studies without F1 hybrid varieties were not included.

Appropriate authorised varieties as well as breeding lines were assigned to the group of open pollinating varieties. Some of the lines studied were later submitted for official variety authorisation; this applies to 20 of the lines studied here. The open pollinating varieties include not only those from biodynamic breeding, but also from organic breeding (see table 3) from varieties developed by conventional breeders or from gene bank origins.

The most important key data and the results of the analyses were systematically recorded and listed in a kind of 'variety database'. The most important results from the reports were summarised in a conclusion.

Results are available for a total of 18 crops (Table 1). A total of 183 varieties were tested in 42 studies, 133 of which were open pollinating varieties including breeding lines and 50 F1 hybrid varieties of conventional origin. Considerable differences in the depth of testing of the individual crops can be recognised. Carrots were tested comparatively intensively (12 experiments with a total of 56 varieties). Only one study is available for each of nine crops. Results from two, three or four experiments are available for the other crops.

Left picture credit: Huon Barlow, Heckfield Place.

Table 1: Overview of the crops analysed.

	Number of analyses	Number of samples	
Crop		**Open pollinating**	**Hybrid**
Carrot	12	40	16
Red beetroot	4	15	4
Tomato	4	6	4
Courgette	3	16	3
Onion	3	10	4
Leek	2	11	2
Kohlrabi	2	3	2
Radish	2	2	2
White cabbage	1	11	3
Radicchio	1	5	1
Celery	1	4	1
Brussels sprouts	1	3	1
Cauliflower	1	2	1
Melon	1	1	2
Chicory	1	1	1
Sweet corn	1	1	1
Sweet pepper	1	1	1
Spring onion	1	1	1

The studies date from 1998 to 2022, with the vast majority - 36 of 42 studies - dating from 2011 onwards. The authors of the studies are Gaby Mergardt, Ursula Balzer-Graf, Christhild Rohmund, Maike Gränzdörffer, Uwe Geier and Roya Bornhütter.

Apart from a few of the older works, the samples were always coded for the investigators. Comparing the results across different cultures and from different laboratories proved to be a methodological challenge. Standardised terms are available for the different visual qualities of the crystallisation images (see Huber et al. 2010, Doesburg et al. 2015). For example, the terms degradation and maturity were defined in detail by Doesburg et al. (2015). However, the application may vary slightly depending on the crop being analysed or the author. In addition, it can be assumed that the evaluation methodology will be further developed, which will increase the variety of characteristics used.

In order to achieve a high degree of comparability, a superordinate concept was therefore required that would allow the visual characteristics from the image-creating methods to be categorised.

The 'Inner Quality Concept'

The 'Inner Quality Concept', developed at the Louis Bolk Institute in the Netherlands, proved to be suitable. The concept was developed to adequately describe the quality of organically produced food. The development was based on experiments on apples and carrots with numerous factors of quality formation, such as light, fertilisation and biodynamic preparations. The Inner Quality Concept describes food quality through the life processes of growth and differentiation (ripening) and their integration. An explicit aim of the Inner Quality Concept is to provide a holistic framework to enable the interpretation of food quality by different laboratories (and methods) (Bloksma et al. 2003, 2007).

For the application to the image-creating methods, the central visual characteristics had to be assigned to the three qualities of the Inner Quality Concept. This assignment was carried out in summer 2023 by Uwe Geier and Gaby Mergardt (Table 2). The variety evaluations from all studies were then scored with regard to the three qualities of *growth, differentiation and integration*. In line with standard variety assessments, we opted for a five-point scale from very low (1) to very high (5).

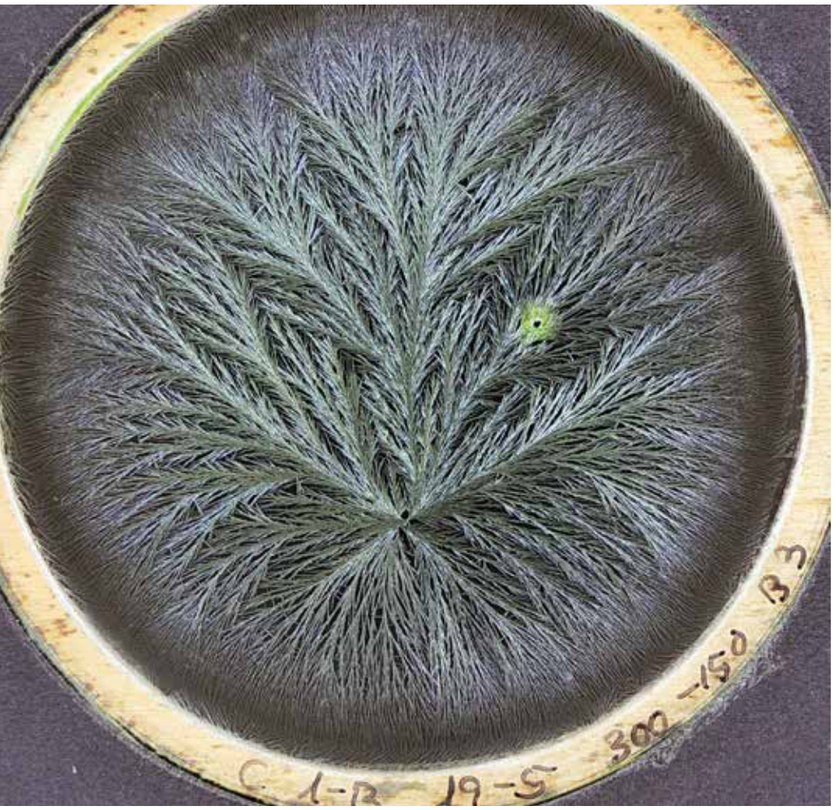
Breeding line of Kultursaat e.V. Distinct integration and uniformity of all structures shown. High substance effect with fruit-like needling. Lively mobility with basic tension of the depicted needles with dynamic radiance right up to the edge of the image.

Table 2:
Assignment of visual image features of copper chloride crystallisation to the three qualities of the inner quality concept of Bloksma et al. (2003).

Qualities of the Inner Quality concept	Features of copper chloride crystallisation Differentiation Integration.
Growth	Substance effect, intensity of form.
Differentiation	Maturity, mobility, presence, clear structures.
Integration	Regularity, connectedness, centre coordination

Open pollinating varieties and F1 hybrids assessed using the Inner Quality Concept

Table 3 shows the mean values of the scores of the 50 F1 hybrids and 133 open pollinating varieties according to the Inner Quality Concept. The smallest differences can be seen in the *growth* quality category. The open pollinating varieties are exactly one grade more favourable than the F1 hybrids. Slightly larger differences can be seen in the quality of *differentiation*, namely 1.2 grades. In terms of growth and *differentiation*, the F1 hybrids together received just under a medium rating, while the open pollinating varieties received just under a relatively high rating. The strongest difference is evident in the quality of *integration*; here the ratings for open pollinating varieties and conventionally bred F1 hybrids are almost two score points apart. On average, the F1 hybrids only received a relatively low rating.



Variety from organic breeding (Gesche): High substance effect with fruit-like needling. Existing basic tension. Needle traits less concise and partly somewhat sticky. Wide image radiation, but without powerful dynamics and with less integration and uniformity.

All in all, the overall comparison shows a higher quality classification of the open pollinating varieties compared to the F1 hybrids. It is necessary to examine why the differences are so great, especially in the quality of *integration*. According to the Inner Quality Concept, *integration* stands for the balance of life processes. In the image-creating methods, it is characteristics such as centre coordination or connectedness that point to balance.

Table 3:
Mean evaluation of the groups of open pollinating varieties and hybrids from 42 independent studies using the image-forming methods based on the characteristics of growth, differentiation and integration of the inner quality concept of Bloksma et al. (2003). Score 1 = low, 2 = relatively low, 3 = medium, 4 relatively high, 5 = very high.

	Open pollinating	Hybrids
Number of varieties or breeding lines	133	50
Growth	3.78	2.78
Differentiation	3.88	2.66
Integration	3.86	1.96

Comparison of biodynamic and conventional open pollinating seed

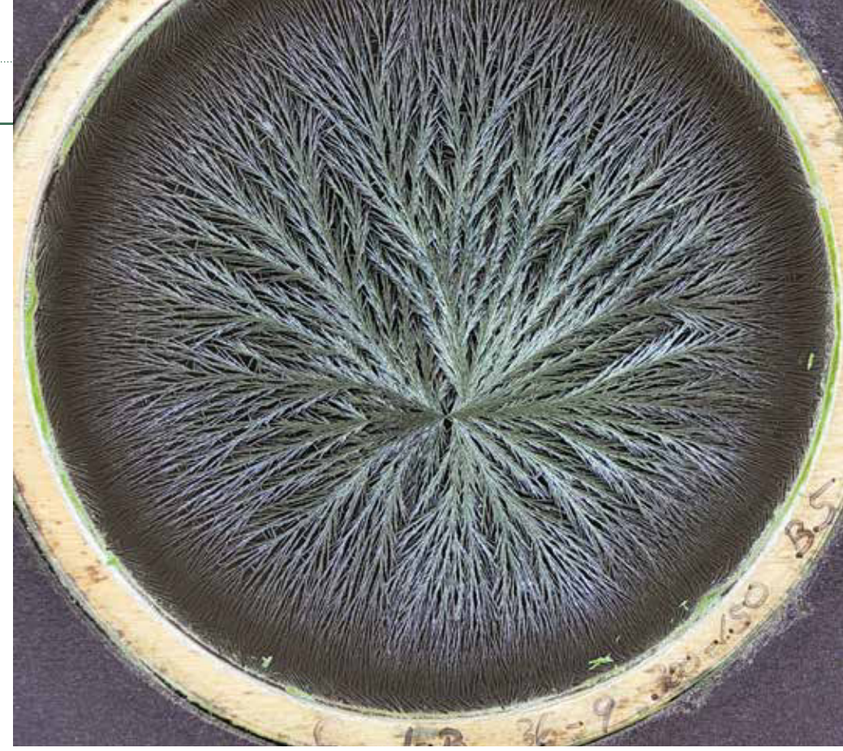
The analysis in Table 3 not only summarises different crops. There is also great diversity in the breeding lines and varieties. For example, all (open pollinating) biodynamic lines and varieties were analysed together as a group with the open pollinating varieties from conventional breeding houses and compared with the F1 hybrids. A comparison of the conventionally bred open pollinating varieties with the biodynamic lines and varieties could show the effect of biodynamic breeding.

However, not all studies included conventionally bred open pollinating varieties. We therefore analysed all trials from our database that included conventional open pollinating varieties in addition to biodynamic lines/varieties and F1 hybrids. Twelve of the 42 trials in total were analysable for this question.

The crops included were carrots (6 trials), beetroot (4 trials), leek (1 trial) and radicchio (1 trial). The data in Table 4 confirm this presumed effect: The biodynamic

varieties and lines are consistently rated higher than the conventional open pollinating varieties in all qualities of the Inner Quality Concept, on average by 30%. The comparison of the conventionally bred open pollinating varieties with the F1 hybrids (all of which have so far been bred conventionally) shows the conspicuous nature of the integration trait. In this quality, the difference between the breeding methods is clear.

Irrespective of the gradual differences in product quality that can be determined between varieties and breeding methods by means of the image-forming methods, qualitative arguments are put forward by authors (cf. Vollenweider 2022) that point to the incompatibility of F1 hybrids with the ideal of the biodynamic farm organism, such as the lack of reproducibility.



Conventional hybrid (Wodan F1): Lower substance effect and plate coverage without concise needling or fruit-like fine dense needling.

Table 4:
Mean evaluation of the groups of biodynamically bred varieties and lines, conventional open pollinating varieties of carrot, beetroot, leek and radicchio with the image-forming methods varieties based on the characteristics of growth, differentiation and integration of the inner quality concept of Bloksma et al. (2003). Score 1 = low, 2 = relatively low, 3 = medium, 4 relatively high, 5 = very high.

	Number of varieties or breeding lines	Growth	Differentiation	Integration
Open pollinating varieties or lines from biodynamic breeding	25	4.0	4.0	4.0
Open pollinating varieties from conventional breeding	22	3.3	3.3	3.2
Hybrids	14	3.1	3.2	2.4

Conclusion

The evaluation of the available image-creating methods and the results of the comparison between open pollinating varieties and F1 hybrids in vegetables paints a clear picture. The group of open pollinating varieties (and breeding lines) receives a relatively high rating in all three categories of the Inner Quality Concept of Bloksma et al. (2003, 2007), i.e. growth, differentiation and integration.

In contrast, the group of (conventionally bred) F1 hybrids only achieved a medium to relatively low quality. A comparison of the biodynamic and conventional open pollinating seed shows the advantage of the biodynamic varieties and lines. The F1 hybrids are particularly unfavourable in terms of integration.

When carried out professionally, the image-forming methods have proven their worth in the evaluation of numerous quality-forming factors of plants and foodstuffs. The effects of cultivation measures have been demonstrated in several scientific publications (cf. Athmann et al.2021, Fritz et al. 2020). Against this background, it is not surprising that the image-forming methods also reveal differences between varieties and breeding methods. A long version of the report and a scientific article on the present study are in preparation.

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