The Breeder's Eye – Theoretical Aspects of the Breeder's Decision-Making[1]

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Abstract

The report describes an empirical research project which investigated the peculiarity and role of knowledge gained through experience in plant breeding from the breeder's perspective. In this paper, a theory respecting the breeder's decision-making process will be presented. The categories of knowledge that are important for the decision-making process will be sketched and three levels of consciousness elaborated. The integration of all levels of knowledge and consciousness is what in the end determines whether the breeder's decision-making activities are competent or not. This complexity is defined as intuition in the sense of an invariant present. The empirical findings will be briefly discussed with respect to their importance to organic agricultural science and organic plant breeding.

Introduction

The history of professional plant breeding is a story of success because the increases in harvests in the 20th century have to be regarded within the context of the development of new varieties through plant breeding. In the scientific literature on the subject, this success story is traced back to developments in the natural sciences, especially in the fields of botany, genetics and statistics.

This interpretation, however, oversees the fact that the scientifically codified knowledge has a broad basis in the experience of the plant breeders. Although the plant breeders and experts are aware of importance of knowledge gained thorough experience and it has even been granted its own category, the "breeder's eye", no scientific studies have been carried out on this topic to date

The significance of knowledge gained through experience has to a large extent been ignored in the relevant literature on the subject or only mentioned in the form of a metaphor, the "breeder's eye". Paraphrased as a "prophetic gift" (Rümker 1889; Broili 1910) or "trained eye" (Kraus 1917; Molz 1917), it does indeed insinuate that significant relevance is granted to experience, but at the same time its qualities, however, do not seem to be more closely definable. With the increasing trend towards more scientific approaches in the textbooks on plant breeding, other synonyms for the "breeder's eye" appeared in the relative literature on the subject such as "eye-jugdement" and "visual selection" (Jensen 1988: 348). The characterizations of the breeder's actions remain, however, rather meagre (Duvick 2002; Lammerts van Bueren 2002). "Patient", "persistent and "interpersonal skills" were specified as the decisive personal qualities of a breeder. In some texts, the success of the breeder's activities was traced back to his insight, intuition and perceptivity (Jensen 1988: 366ff; Duvick 1999; 2002).

As manifold and enlightening the findings from such studies are, the breeder's concrete praxis is not taken into consideration in them. The breeder's daily life is characterized by innumerable decisions which could hardly take place without a reserve of experience he can fall back upon. The breeder's decision-making behaviour is, therefore, the key category if one wants to understand plant breeding and its success. The following study deals with the subject. Based on the example of the crossbreeding of self-fertilizing cereals, the breeder's decision-making activities will be reproduced and analysed in each specific temporal-space, situational context. While taking the complex knowledge of the breeder into account, a theory of the breeder's decision-making behaviour – the breeder's eye – will be developed.

Methodology

The investigation of this very personal field of knowledge took place in the form of a qualitative-empirical sociological study. The research describing the breeder's own experience gained at the

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beginning of his career as a plant breeder endeavours to document the special quality of knowledge gained through experience. The decision-making process is the focus of interest. This participatory observation approach (Spradley 1980) was complemented by five interviews with cereal breeders. The collection and analyses of the data as well as the design of the research process was based on the "grounded theory" principles (Glaser et al. 1967).

Findings

In the following, three levels of consciousness will be differentiated on the basis of three different praxis elements which are closely interlaced in workday breeding routine (organization activities, selection and cross-breeding planning). The last two elements are concerned with the decision-making process in breeding in a narrow sense. It is always about decision-making in a concrete situation. Before that aspect is dealt with, a brief description of important categories of knowledge will be presented. The diverse dimensions of decision-making in the field of breeding will be made transparent against this background.

The Breeder as a Farmer – Vegetational Consciousness

In general, the most important tasks are similar each year and are comparable to those that take place on a farm. The various breeding tasks are oriented towards the development of the vegetation. Taking the wetter and soil conditions into account, sowing, cultivation measures and finally the harvest have to be planned and carried out. From this perspective, many of the tasks are similar to those of a farmer.

The planning and utilization of the available resources takes place in accordance with the specific breeding goals. The tasks are planned and executed if possible in such a way so that the interesting phenomena appear to be "well differentiated". Only in this manner can appropriate decisions be made. In order to differentiate well, numerous efforts have to be made: special successions of crops are decided upon, or artificial infections are introduced in order to aggravate the appearance of specific diseases, or sowing is carried out at an especially early or particularly late date in order to test the appropriateness under extreme conditions and to make the selection in accordance. These are often the measures that a farmer would frequently *not* carry out.

For the breeder, the organizational activities and the resource planning are linked to their way of perceiving the vegetation cycle. The employment of temporary workers and assistants has to be planned and steered in accordance with the available resources. Evaluations, harvest tasks, processing tasks or analyses have to be planned so that the necessary data are available in the "decisive" situations. The decision-making situations, especially with respect to selecting, take in the case of winter corn place in the period between the harvest and the next sowing as well as the vegetation period in the following spring. Along with the vegetation, the breeder also experiences the growth of the breeding line under the conditions of a specific year and place.

The temporal order of the growing process along with the aspects of the organizational activities and resource planning comprise the level of the vegetational consciousness. Although important aspects of the breeder's activities are touched upon and the temporal order can be grasped by a non-breeder, the breeder's decision-making process cannot be understood that way. It only becomes transparent when the diverse generations of the varieties are taken into account. Before that is explained, a brief overview of categories of knowledge will be presented.

Categories of Knowledge and Decision Matrixes

The breeder's decision-making activities are based on knowledge that is present at various levels during the decision-making process. The fundamental categories of knowledge will be briefly characterized in a first step and brought together in a second step in order to develop a decision matrix.

Sensorial Presence

Sensorial presence purely signifies sensory perception. Although the visual sense dominates, other senses are also involved: tasting and smelling while checking the taste of backing trials, evaluating the firmness of the loaf. The sensorial presence *is* presence. The contents of the sensorial presence can be very different in accordance with where the breeder is at the moment: investigating the plants in the field or data in his office.

Mental Presence

The term “mental presence” signifies the notion of the configuration that is present in the imagination of the breeder when considering a breeding line. As a significant part of experience, it can hardly be explicitly perceived (Polanyi 1985/1966). Mental presence does not mean a static momentary impression but rather a configuration won in time-space contexts. The course of the vegetation conveys the time configuration, and cropping in various locations the space configuration. Mental compactness is defined as the experience gained over many years and in many places. Mental presence is generated in the past and can be called up in the presence and serve as guidelines for future actions.

Knowledge Derived from Data

Knowledge derived from data is data material that is collected in very different measuring acts: evaluation data, analysis data, yield data. As characters (numbers) they are physically present and have to be interpreted before they become data knowledge. This interpretation act is also an act which gives them a frame that embeds the data in a specific space-time, generation context while taking into account knowledge of the methodological ability to make a statement. The interpretation does not lead to the fact that the data material is all encompassing, but the interesting data “entangled in chronicles” (Schapp 1976). Through the act of interpretation, the data *becomes* history.

Chronicle Knowledge

Chronicle knowledge is also present in decision-making activities. The existing chronicles, e.g., the chronicle of varieties and their descent comprise various aspects: graspable characterization categories capable of being designated that are capable of making a statement without personal experience and the data knowledge entangled in these chronicles. Both aspects signalize that with the exception of fundamental basic experience in terminology *no* personal experience with a particular, concrete breeding line is necessary. The mental presence, on the other hand, can *only* be established by means of personal experience; it is associatively implied in the chronicles. The chronicles as such are dynamic: some aspects are forgotten, new aspects are added. The older the chronicle, the more it gains the character of an anecdote. Chronicle knowledge is knowledge generated in the past.

Breeding Goal

Breeding pursues a goal. The “targeted” goal can, as a rule, only be achieved after 10 to 15 years. The expectations with respect to the efficiency and the appearance of a variety are established and fixed with the goal itself. The above-mentioned mental presence and data knowledge categories are, however, formulated here as expectations. The breeding goal accompanies the selection activities in the subsequent generations. Generally clearly articulated during the cross-breeding planning, it can alter and lose importance in advanced generations. The breeding goal is part of the chronicle of the variety. In a concrete decision-making situation, it anticipates the future.

Decision-making Matrix

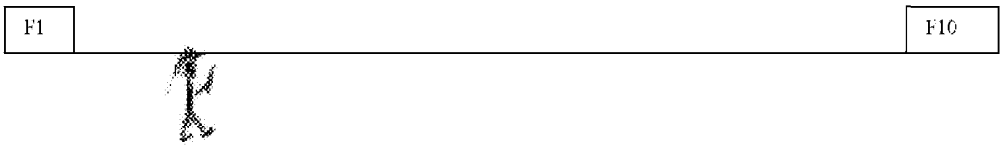
These separately sketched categories of knowledge help to illustrate the many-dimensional decision-making process in a concrete situation. The decision is preceded by a process of weighing the factors that can, according to the specific decision-making situation, comprise several categories of knowledge. In the concrete decision-making situation, the breeder has either plants, grains or numbers in front of him in accordance with the place where the decision is made (sensorial presence). The breeder has a more or less well-constructed notion of a breeding line or from the parents (mental presence). He knows the chronology (chronological knowledge). He already has data in front of him that have been interpreted with respect to their space-time context (data knowledge). That is confronted by the breeding goal that points towards the future and formulates specific properties as expectations and these, once again, as form and data expectations. The balancing out of these three levels – presence and existence, experience and knowledge, breeding goal and expectations – lead to the decision. This decision-making matrix, however, does not take the weighing of the individual elements of knowledge in the diverse decision-making situations into consideration. This will be briefly sketched in the following.

The Selection Activities – the Generational Consciousness

After crossbreeding, the next generation grows on the ear of corn, the first filial generation or “F1”for short. A new variety can grow out of each F1-corn. This is decided by the breeder’s selection activities in the subsequent years. From “F2” on, the combination of the parenthood properties “split” significantly and only after approximately 6 years can one calculate with a constant hereditary transmission. By means of continual selection activities during this time, the desired properties are selected over the years until all of the properties are “genetically homozygous.”

A Generation Cycle – Early and Delayed Selection in Contrast

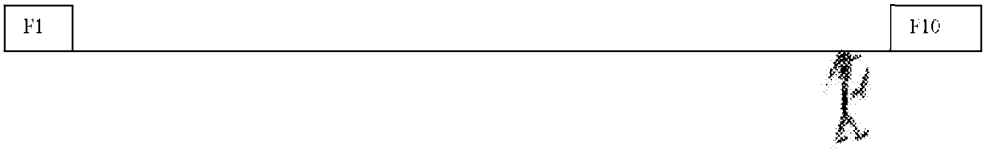
Early Selection:



In the first few years, the basis of judgment is considerably limited to the plants growing in the field. It takes years before enough data are collected. Too little of a breeding line can be harvested to test the yields. Despite the restricted data basis, approximately 90% of the selection decisions must be made during the first three generations (Becker 1993).

The sensorial presence plays an important role in the selection activities during this phase. Disease, reactions to deficiencies and the height of the plants are examples of factors that can be easily judged during this phase. The evaluation is made on the basis of the available knowledge about the parent plants that are physically not present (mental presence). The properties and descent of the parent plants (chronicle knowledge) are passed on in the chronicles of one of the parent plants. If the breeder has had personal experience with the parent plants, they are mentally present when the breeder envisions the new variety (mental presence). Mentally present knowledge plays a significant role during this phase; however, it centres on the parents and not the breeding line itself. The young breeding lines are first appraised, then analysed and finally their peculiarities and productive capacity are studied on the basis of the yields. In this phase of a breeding programme, the selection decisions are made during the vegetation period, the harvest of the elite ear and the appraisals of the corn during the preparation for sowing.

Delayed Selection:



More and more data are collected over the generations. The data basis for judging a breeding line grows continually and becomes broader. The appraisals of many different properties by checking the yields and analysing the quality make the productive capacity of the diverse breeding lines in different habitats more and more clear. The breeders make efforts to visit all of the locations at least once. The breeding line itself writes its own chronicle. The chronicle is filled with the experiences gained in the past years that, in accordance with the age of a breeding line, gradually represent the breeding line. The growth phases have been experienced over the years (temporal configuration). Limited to one location in the beginning, the test cropping expands to various locations which gives the breeder the opportunity to experience its characteristics in various locations (spatial configuration). The temporal and spatial configurations make it possible for the breeder to evaluate the potential of the breeding line. They indicate a characteristic of the breeding line that is mentally present and of major importance for further decisions. The singular sensorial confrontation loses importance. It becomes part of the overall impression. The tremendous amount and density of data in subsequent filial generations is framed by the mental presence of the breeding line. Mental presence and data knowledge determine the breeder's decision making during this breeding phase.

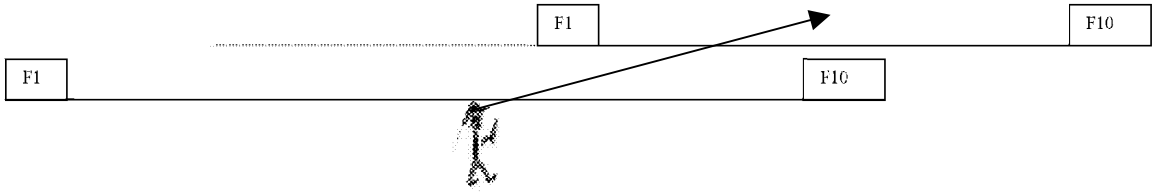
If the selection decision is based during the early generations on the sensorial presence of the still young breeding line, the chronicle knowledge about the parents plants and the mental presence of the parent plants, the fundamental knowledge sifts in the course of the generations to become data knowledge and the mental presence of the breeding line itself. The breeding line now writes its own chronicle. The breeding goal loses its importance over the course of the generations. The breeding line has to be convincing on the basis of its efficiency and the selection activities can no longer influence it. The place the decisions are now made is in general an office.

Generational Consciousness

In contrast to the breeder in his role as a farmer (vegetational consciousness), during the selection activities, the consciousness expands to include the entire generational cycle (generational consciousness). The breeder, male or female, has to keep all of the generations in mind. He or she has

to know what can be meaningfully evaluated in which generation and when important decisions have to be made. Methodological security is linked with generational consciousness.

Planning Crossbreeding – Consciousness in Hereditary Flow



Planning crossbreeding is another key decision-making situation in modern cereal breeding. As a rule with respect to winter grain, it generally takes place in winter in an office. When the planning is being carried out, the parents whose properties complement each other with regard to the breeding goal are combined. Frequently the basis for the crossbreeding planning are approved varieties, or – upon a mutual agreement between the breeders – nucleous breeding stock from the current variety which is being evaluated. The combination takes place in this context on the basis of the available data and the known properties. The crossbreeding planning, however, also includes firm internal breeding lines. From the phase F5 on, more and more questions arise: What can the breeding line offer? Will it become a new variety, should it be discarded, or does it offer valuable properties that, although they do not suffice for an own variety, should be preserved and further developed thorough further crossbreeding?

The crossbreeding planning is with respect to the involved categories of knowledge the most sweeping. The chronicles of the own breeding lines are known. The comprehensive data are embedded in the mental presence. Data knowledge and mental presence determine the choice of the new crossbreeding partner that complement the properties of the breeding line and can develop it further. The sensorial presence has a correctional influence at most. The significance of the properties that are to be further developed are the focal point of interest; the real breeding line is "only" the carrier of the properties. The awareness of the properties rises above the sensorial presence of a breeding line and becomes a flow of properties, to an awareness within the hereditary flow of the properties. When planning the further crossbreeding of one's own breeding line, there is, hence, another level that is based on a profound knowledge of the breeding material.

Conclusions

In order to understand the decision-making activities of a breeder, it is necessary to take the situational context into consideration. That determines at which point in time it is possible to make a meaningful decision. The breeder's knowledge is based on hybrid knowledge composed of knowledge gained through experience and scientific knowledge. The complexity determines the intuitive character of the breeder's decision-making activities. Intuition in this context does not mean an intuitionally-based arbitrary decision but rather a well-founded decision that is, however, due to the complexity of the individual determinants difficult to describe. The intuitive character is reinforced by the necessity to make many thousands of decisions within an extremely short period of time. The presence and skillful integration of all time, space and knowledge levels in a decision-making situation is what determines in the end competent breeding decision-making activities and endows the experienced breeder with the breeder's eye.

In contrast to discursive cognizance that is based on sense perception and conclusions based on one another, intuitive cognizance – in this context as a basis for a decision – can be conceived as a 'mental conception.' Thus one of the basic concepts of Edmund Husserl's phenomenology is the so-called "Wesensschau" (taking a look at the essence or substance itself) that makes it possible to find access to the intrinsic structure of an object and abstract it from the individual particularity or chance variations. The invariant is present in intuition, in direct contemplation (Lübcke 1998: 81ff.). The significance of intuition as the recognition of the invariant is also clear in the breeder's decision making.

The findings prove that intuition – which is called here 'the breeder's eye' – must be understood as the integration of many levels of knowledge. It also plays a role in modern plant breeding which is scientifically based. Scientific knowledge and knowledge gained through experience are not opposites but rather complementary fields of knowledge. Analogously, it can be presumed that intuition is also

present in other disciplines within the field of agricultural science. Intuitive knowledge should be taken seriously and made accessible to research methodology. The goetheanists (goetheanism) and the phenomenology of nature (Timmermann 2005) have dedicated themselves to this task.

The impulse leading to the organic movement and, in particular, organic farming was the subjective consternation of the individual faced by the destructive treatment of nature which led to a quest for alternatives. Taking subject-oriented knowledge seriously has, hence, to be a natural part of the organic discipline in agricultural science. Subject-oriented forms of generating knowledge must imperatively, thus, belong to the research methodology used in an organic agricultural science and organic plant breeding.

It is extremely important for the organic plant breeder to learn to understand the significance of the multiple sensorial phenomena and, in so far as meaningful, to incorporate and materialize them in the new varieties. That, on the other hand, means that the breeder must intensively study the material that can only be achieved by proceeding professionally in a communicative context with organic farming.

References

Becker, Heiko (1993) Pflanzenzüchtung. Stuttgart, Ulmer.

Broili, Josef (1910) Betrachtungen zu dem Berufe des Pflanzenzüchters. Fühlings landwirtschaftliche Zeitung 59: 594-600.

Duvick, Donald N. (1999) The profile of a plant breeder for the third millenium. A. Borem and M. P. d. Giudice. Plant breeding in the turn of the millenium. Brazil.

Duvick, Donald N. (2002) Theory, Empiricism and Intuition in Professional Plant Breeding. D. A. Cleveland and D. Soleri. Farmers, Scientists and Plant Breeding, CAB International.

Glaser, B. G. and Strauss, Anselm L. (1967) The Discovery of Grounded Theory, Strategies for Qualitative Research. New York, Aldine.

Jensen, Neal F. (1988) Plant Breeding Methodology. John Wiley&Sohns: New York u.a.

Kraus, Carl (1917) Untersuchungen über die Vererbungsverhältnisse bei Nachkommenschaften reiner Linien. Fühlings landwirtschaftliche Zeitung 66: 457-486.

Lammerts van Bueren, Edith T. (2002) Organic plant breeding and propagation: concepts and strategies. Wageningen, Wageningen University/Netherlands.

Lübcke, Poul (1998) Edmund Husserl, Die Philosophie als strenge Wissenschaft. A. Hügli and P. Lübcke. Philosophie im 20. Jahrhundert. Hamburg, Rowohlt Verlag. Bd.1: 68-109.

Molz, E. (1917) Über die Züchtung widerstandsfähiger Sorten unserer Kulturpflanzen. Zeitschrift für Pflanzenzüchtung Bd.V: 121-235.

Polanyi, Michael (1985/1966) Implizites Wissen. Frankfurt a.M., Suhrkamp.

Rümker, Kurt von (1889) Anleitung zur Getreidezüchtung auf wissenschaftlicher Grundlage. Berlin.

Schapp, Wilhelm (1976) In Geschichten verstrickt - Zum Sein von Mensch und Ding. Wiesbaden, B.Heymann.

Spradley, James P. (1980) Participant Observation. New York, Rinehart&Winston.

Timmermann, Martin (2005) Phänomenologie der Natur: methodologische Aspekte einer die quantifizierenden Naturwissenschaften erweiternden Forschungsweise, http://orgprints.org/3724