

Science and Scale – Application of Knowledge in 20th Century Swedish Agriculture

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Gabriel Söderberg, Department of Economic History, Uppsala University

Scientific knowledge has an ambiguous relationship to the social system that creates it. On the one hand a key ideological aspect of the gathering of useful knowledge is to enlighten the path of humanity and better its lot. On the other hand knowledge of this kind can confer critical economic leverage if it can be contained and used to produce superior goods to be sold on the market. To this must be added the fact that considerable resources must in general be spent before knowledge of this kind can be produced. This means that different actors differ in the resources they can either invest themselves or the resources they can use political influence in order to induce public authorities to invest in knowledge creation. And if such knowledge is created and applied in the production process, there must be means to make sure that the increased efficiency does not result in too severe price drops – otherwise there will be no real incentive to initiate the process. Traditional Swedish agriculture, at the threshold of modernization, thus comes out as an interesting case. Consisting of many small producers, with some notable exceptions, this sector can be expected to have had problems of generating enough resources to initiate development processes, coordinating pressure on the state to initiate modernization, and coordinating market actions to make sure that resulting price drops did not follow. The fact that the sector still modernized opens up a number of interesting topics, approaches and interpretations.

This paper will approach one part of this problem by studying how plant breeding as a means to modernize Swedish farming, was implemented in Sweden. Due to lack of space it will focus on the improvement of wheat, though the process described had bearings on other plant types as well. The research question is: How did the market structure of Swedish wheat farming affect the way scientific knowledge was created and implemented to improve the quality of the cultivated wheat?

Theoretical considerations

In his 1942 work *Capitalism, Socialism, and Democracy*, Joseph Schumpeter castigated the classical economical model that idealized a market consisting of many small producers in which no one had any market power what so ever. The facts and arguments of this work tended to, he summed up, “dim the halo that once surrounded perfect competition as much as they suggest a more favorable view of its alternative.”¹ For the situation on the perfect market was a static one in terms of innovation and progress. Market power was needed to “gain time and space for further developments”.² The motor of progress was therefore the large industrial enterprises that constantly churned out new production methods and new types of goods, constantly renewing its own market power. Bringing with them higher standards of living for the masses, these oligopolistic powers were the root to progress while competitive sectors were incurably back-wards:

The introduction of new methods of production and new commodities is hardly conceivable with perfect – and perfectly prompt – competition from the start. And this means that the bulk of what we call economic progress is incompatible with it.³

While it is dangerous to claim that perfect competition, being a purely theoretical concept, has ever existed in real life, it is clear that a sector can be more or less close to it. Traditional Swedish agriculture, before extensive regulations, with its many small producers would come close to it. Schumpeter explicitly mentioned agriculture as opposed to the more concentrated industrial ventures. In fact much of the progress in agriculture, that he did not deny, was a result of the actions of the imperfect market conditions in industry:

As soon as we go into details and inquire into the individual items in which progress was most conspicuous, the trail leads not to the doors of those firms that work under conditions of comparatively free competition but precisely to the doors of the large concerns – which, as in the case of agricultural machinery, also account for much of the progress in the competitive sector...⁴

Thus, according to Schumpeter, there is something of a spill-over effect at work here: the advances of the oligopolistic industrial sectors spread to the competitive sectors which are given a boost that is not of their own making.

Schumpeter did not, to my knowledge deal with the economic results of scientific knowledge. This has however been taken up in recent decades by proponents of Endogenous

¹ Schumpeter (1976), p. 103.

² Schumpeter (1976), p. 89.

³ Schumpeter (1976), p. 105.

⁴ Schumpeter (1976), p. 82.

Growth Theory that stresses the importance of market incentives by firms to engage in research and development.

Brief background on plant breeding and Swedish agriculture

Plant breeding without direct knowledge about the process of inheritance or genetic change has probably taken place for many millennia. Some individual plants probably attracted attention due to their unusual appearance, and their seeds were collected for further use. The Squarehead wheat, for instance, whose high yield but poor baking quality set up a key challenge to modern plant breeding, seems to have originated spontaneously in the fields of northeastern England. It was discovered in the 1860s by a Yorkshire farmer who saw “a wheat plant of unusual appearance” and brought it to the attention of breeders who refined it and began to market it. A Danish firm purchased seeds of this type in 1874, and began selling them in nearby areas, including southern Sweden.⁵

Victorian science and theories on evolution presented a conceptual structure according to which it would be possible to systematically improve the nature of cultivated plants. Though Darwin himself had no knowledge of genetics, the notion of hereditary changes helped to inspire systematic attempts to improve plants. The rediscovery of the Mendelian laws of inheritance in 1900 led to methodological changes – and a clash with Darwinian interpretations⁶ – as well as a more lasting theoretical foundation for plant breeding.

The sector under study here to which these new ideas of plant improvement was of interest, Swedish agriculture, went through a number of crises that culminated in the creation of a regulatory mechanism in a historical deal between farmers’ representatives and the ascending labor party in the early 1930s. The world agricultural crisis of the 1880s, with falling prices on agricultural products, hit Swedish farmers severely. Calls for tariffs on imports divided the country in two, finally resulting in a moderate tariff in 1888. Another round of crisis followed in the early 1920s, and then in the late 1920s and early 1930s. The complex regulation mechanism implemented in the 1930s not only ensured financial support to farmers, but also initiated a more aggressive modernization scheme. In order to shed light on the effect of the

⁵ SUT (1936), pp. 199-200.

⁶ Widmalm (1999), pp. 251-253.

market structure on the use of plant breeding to improve grain, it is therefore necessary to focus on the decades between the 1880s and 1930s.

Market composition

Being a country with considerable regional differences in geographical conditions, Sweden varied also in the types of grains cultivated in different regions. There were also differences in the types of grain cultivated by farms of different sizes, and most probably cultivated more than one type of grain. This makes it difficult to construct a detailed representation of the actual market structure for a specific type of grain. Table 1 below can only be seen as an indicator for the market structure for wheat, but still gives a vivid picture of a sector consisting of many producers the bulk of which are below 20 hectares in size.

Table 1. Number of agricultural holdings in Sweden of various sizes in hectares (ha) 1885-1932

Year	0,26-2 ha	2,1-20 ha	20,1-100 ha	>100 ha	Total
1885	81 990	212 542	33 776	3 509	334 371
1895	71 258	215 479	32 553	3 154	331 679
1905	88 827	223 186	33 552	3 257	352 897
1919	120 788	270511	34 883	2 576	428 758
1932	121 238	271 887	33 097	2 395	428 617

Source: Swedish Agriculture in figures 1800-2004, p. 16.

The historical statistics excludes minor land holdings, such as cottages, until 1919 when the statistical categories are revised. This means that comparisons pre and post 1919 must be done with care. Still, the picture emerging here is one of many small producers.

On the other side of the market transaction was the refinement industries. In the case of wheat the relevant industries are the mills that bought the grain, or took part of the total grain as a fee, processed it into flour, and then sold it to the bakeries. The tariffs of 1888 ensured

protection not just for Swedish grain, but also Swedish flour. This together with technological advances in powering large-scale mills, led to the establishment of several mills organized on the line of industrial corporations in the late 19th century, and a severe over-capacity that threatened the profitability of these establishments.⁷ A cartel in order to, in their own words, “end a very sharp and for all parts costly competition” was established in 1913.⁸

Focusing on the market for wheat, the question now becomes: how did the market situation of many small producers and a few large buyers affect the improvement of the good? First a look on how initiating plant breeding, with all the resources it demands, can be solved in a competitive sector.

The Possible Constellations of Plant Breeding

Using conventional wisdom and applying it on agriculture, development of better crop would go something like this: A farmer initiates plant breeding on his farm. With time his crops will become better. He sells these better crops on the market. The buyers recognize that his product is superior to those of his rival and he is thus able to secure a larger profit which rewards him for the resources vested in the development process. But this is not what we see in real life. Instead we see that plant breeding has been separated from the producers, and is instead supplied to them together with other inputs that cannot be produced on the farm, such as fertilizers and farming machinery. Many circumstances, including increasing societal division of labor as well as the complexity of biological processes, together make a plausible explanation for this. However, a compelling explanation remains the lack of scale and market power of the agricultural producers. With a market consisting of many small producers, using the described theoretical framework, development would not occur, unless exogenous forces or actions taken by the producers themselves to counterweigh the lack of scale are initiated.

Several arrangements can be suggested to achieve this. First, a company operating more on the line of an industrial corporation can be formed. This is how most of the production of farming machinery, tractors and combined-harvesters for instance, has been organized – as Schumpeter also suggested in his spill-over view of progress from oligopolistic sectors to competitive ones. Such a firm would organize efforts to achieve new types of seeds out of

⁷ See Kylebäck (1974), pp. 169.

⁸ Kylebäck (1974), p. 170.

which crops with superior qualities can be grown and then sell them to agricultural producers as any other type of input. A patent regulation would be required, since the buyer once he has the seeds can use them in order to produce more seeds of the same kind and not only build up his own stock but also sell it to others. Such a patent system would encourage the creation of new seed, but would also hinder its diffusion, creating a trade-off situation if one wants to maximize modernization of the entire sector.

Second, a breeding organization can be set up in public regime, either through government means or by a privately operated foundation. The motive behind this would not be for profit, as above, but for some perceived furthering of human welfare. A state might wish to modernize its agriculture, but decides that profit incentives are not great enough to leave it in the hands of business. Or it might wish to maximize diffusion of the new seeds by making them cheaply available, and thus invests public resources. A non-profit foundation might fund breeding in order to further philanthropic goals, such as breeding new types of seeds and then distribute them among poor farmers. A complicating factor here is that seeds are not isolated pieces of technology: they are often bred in order to fit into a technological setting, often involving other inputs such as machines, fertilizers, or pesticides; a chemical corporation, for instance, might thus be interested in selling new seeds cheaply in order to increase sales of fertilizers or pesticides, thus blurring the line between philanthropy and business interests.

Third, producers can join forces in an association or cooperative in order to achieve enough scale in order to initiate breeding and then arrange distribution of the results. Finance of this activity would ideally rely on the members paying a fee, but it is also possible that other organizations would contribute or enter in cooperation with it. The situation facing this kind of arrangement is a certain recipe for a free rider problem: being a member entails paying a fee, and if it is possible to somehow get the benefit of the breeding activity without being a member, i.e. getting access to the new seeds, then there is no real incentive to join the association. The state might therefore be interested in somehow giving sanction to such an association, thus making membership compulsory, or helping to finance it – in essence making all tax-paying citizens members.

These three ideal models can probably in reality be mixed. I now turn to an exposition on how plant breeding was organized in Sweden.

Swedish Plant Breeding

Simplifying, Swedish plant breeding was dominated by two of these kinds of arrangements, with severe tension and competition between them. The commercial firm Breeding Institute of Weibullsholm (*Weibullholms förädlingsanstalt*), henceforth referred to as Weibulls, represents the first model. The third model is represented by the Swedish Seed Association, referred to in the future as the Seed Association. It appears that the Seed Association was the most dominant in Sweden at least during the first decades of the 20th century – figures from 1932 estimate that 78% of all cultivated Swedish land was sown with seed from the association.⁹ This is the main reason why this study will focus mainly on the Seed Association. Nevertheless Weibulls was an important actor and competitor to the Association. Especially its spring wheat types seem to have been successful, accounting for no less than 85% of all spring wheat sown in the mid-1950s.¹⁰ Not least did its organizational form constitute a challenge. Since 1993 the two organizations are merged into one corporation, which from 2008 is owned and operated solely by the agricultural cooperative Lantmännen after the co-ownership with German chemical corporation BASF was ended.¹¹

Weibulls – a short background

Chronologically Weibulls started up first. Its founder Walfrid Weibull began selling root-crop seeds in 1870 from his estate Weibullsholm.¹² This activity emerged out of his own attempts to increase production of root-crops in order to better the feed of animals and thus increase their productivity. Initially seed selling took place on a very small scale, with members of the Weibull family themselves sewing and packing packages of seeds in the dining hall of the Weibullsholm estate. But with time both the company and its organization grew, reaching 100 sales agents placed around Sweden in the late 1890s and above 1000 in 1918. Parallel to the development in size was the introduction of more systematic methods for breeding, while trained scientists were employed and analysis equipment procured. Since 1901 Weibulls also engaged in the breeding of grain, resulting in their first winter wheat type *Iduna* in 1912, which was unable to cope with competition from the *Pansar* wheat bred by the Seed

⁹ SUT (1932), p. 185.

¹⁰ Fajerson (1997), p. 43.

¹¹ Lantmännen SW Seed, Homepage, 10/8/2010, [Historia].

¹² The section on Weibulls is based on Fajersson (1997 pp. 35-50,) , Widmalm (1999), pp. 237- 240, and Weibull (1970), pp. 7-49..

Association. More successful types were launched in the years to come as the the company increasingly ventured into the area of grain breeding. The agrarian crisis of the 1920s hit Weibulls hard, and the company applied for state support invoking the large reward to society from its activities and the lack of a patent system. The state finally agreed and in 1924 paid out a sum of 100 000 kr – that year covering 70% of the company’s total expenses – and from then on kept financing a considerable part of the firm’s expenses.¹³ This increased connection between the public and Weibulls gave rise to a state investigation that proposed a reorganization of the Seed Association along the line of a commercial enterprise with state support, which would thus put the two rivals on the same organizational basis. This was supported by Weibulls but furiously resisted by the Seed Association and the proposal was voted down in parliament.¹⁴ Benefiting from state support, however, and from the stability of the regulated post-crisis years, Weibulls was able to expand, including branching out into other countries, during the decades to come while working both nationally and internationally for the creation of a patent system of plant breeding. As such a patent system was introduced in 1971, support from the state subsided. The firm soon entered a period of being part of various industrial concerns, before being bought by Lantmännen in 1991.¹⁵

The Swedish Seed Association, Organization and Purpose

The Swedish Seed Association, in its earliest, form was founded in 1886 on initiative of Birger Welinder, a young estate owner in the town Svalöf in Skåne, which henceforth became the headquarter of the association.¹⁶ Welinder managed to convince several leading estate owners, scientists, and officials of various state-sponsored agricultural organizations to form an association with the stated purpose to “work for cultivation and development of improved grain and seed types and to the spread of this cultivation domestically and abroad”.¹⁷ These seeds were then to be sold to farmers through an independently set up firm, The General Swedish Seed Company – something that was to become pointed out in the years to come as undermining the scientific objectivity of the association. Beside this main objective the association also stated a number of other tasks, for instance: to gather foreign plants and

¹³ Weibull, W (1970), p. 51.

¹⁴ This struggle has been investigated by Sven Widmalm in Widmalm (1999).

¹⁵ Kuylenstjerna (1997), p. 62.

¹⁶ The passage on the Seed Association is based on Olsson (1997), and Widmalm (1999), pp. 234-237, unless otherwise stated.

¹⁷ “Sydsvenska Föreningens för odling och förädling af utsäde årsredovising 1886”, bilaga, p. 4.

cultivate them on Swedish soil in order to assess their potential value, to gather and compile knowledge on plants grown in different parts of Sweden, to arrange seed and grain exhibitions, and to implement a system of control and validation of seeds resulting in the quality approval of the association.¹⁸

How can we understand the creation of such an association? First of all the intellectual currents of the time are hard to dismiss. Modernization through introduction of new technologies, increased reliance on scientific principles, and a general optimistic outlook on the power of science and technology were or were becoming wide-spread. This went for agriculture as well, though the traditional methods used in many quarter of this ancient sector seemed to be the very manifestation of backwardness. Modernistic tendencies existed not only among estate owners, but also among small farmers. The founders of the Seed Association clearly identified themselves with the continual march of enlightenment, referring to the “great progress in all areas that is the hallmark of this era” in the 1886 statement of the goals of the association.¹⁹ This great progress had also entered agriculture: draining of fields, introduction of artificial fertilizers, importation and breeding of more productive live-stocks, and the labor-saving blessing of mechanized plowing and harvesting – all had converged to create higher productivity. But when it came to the betterment of the very root of farming – the cultivated plants themselves – few attempts had been made. The situation remained “on old traditional footing” in stark contrast to the benefits to be made from creating better cultivation stock.²⁰ Such activities could not, the founders argued, be carried out by the farmers themselves. Evaluating the potential reward of a new type of seed demanded scientifically rigorous experimental fields, with time-consuming supervision and analysis. The task therefore belonged to “the scientifically trained expert, who can devote his time to this alone and then to the betterment of agriculture collect and communicate” the results to the farmers. These farmers were instead to support the association’s activity through becoming members, and then reap the rewards through being able to purchase better seeds. Pooling of resources on a local level was also not enough, as was pointed out in a letter sent out to the Agrarian Societies in 1887:

The benefits of the existence a central institution for such cultivation and breeding, where the necessary refinement of our cultivated plants is carried out, is obvious. A thorough plant

¹⁸ Ibid.

¹⁹ Ibid., p. 3.

²⁰ Ibid, p. 4.

breeding can only be performed by experts...and it would probably involve too large costs for smaller local associations to hire such scientifically trained experts.²¹

The Seed Association thus aimed to fill a function that seemed not only possible but necessary. The producers themselves did not have knowledge or time enough to better their own products, but neither did they have – individually or on a local pooling level – enough resources to hire others to initiate this activity of critical importance. The result was that a fundamental part of agriculture remained backwards, which the Seed Association promised to remedy if it could only receive financial support.

Another importance part of the context of the Seed Association's creation is the severe agricultural crisis of the 1880s. As mentioned in chapter two, the low world prices on grain led to severe conflict between free trade enthusiasts, both urban and rural consumers, and those who wanted to protect Swedish grain producers. The country appeared to be ripping itself apart. Andreas Hasselgren in his account of the reign of King Oscar II published 1908 recalled: "The waves of struggle ran high both in the press and on popular meetings, old party bonds were dissolved and the entire nation was divided in two camps with the battle cries of for or against tariffs."²² With falling grain prices and rising support of tariffs, the government in 1886 initiated the so-called Welfare Committee to explore the possibilities of relieving the economic pressure without having to deviate from free trade. Several solutions were suggested by the committee, with measures for overcoming the difficulty of farmers to get access to credit receiving special emphasis. This included arranging a special fund for the financing of building sub-surface drainage systems.²³ While the committee has to be referred to as a failure – its suggestions were presented too late to influence the decision process²⁴ - and tariffs were implemented in spite of it in 1888, the concept presented here is important: measures could be taken to improve the economic performance of the agricultural sector which would let it flourish without necessarily implementing tariffs. While the on-going agrarian crisis is not explicitly mentioned in the 1886 statutes of the Seed Association, it is difficult to believe that the founders were not influenced by the severe social problems arising from it. Probably the association wanted to avoid any reference to the crisis due to the political seriousness of the dividing line for or against tariffs -the fledgling association simply wanted to avoid enraging any of the two sides. Possibly the stated objective to increase the quality of the cultivated plants was also so obviously linked to the alleviation of the difficult

²¹ "Allmänna Svenska Utsädesföreningens årsberättelse för 1887", Bilaga B, p. 19.

²² Hasselgren (1908), p. 254.

²³ Thysseius (1896), pp. 473, 479.

²⁴ Montgomery (1921), p. 154N.

situation of the agrarian sector that mentioning it would be superfluous. In any case, that the crisis was at least part of the rhetoric of the new association is evident in a letter it sent out in 1887 to farmers around the country in order to convince them to join as supporting members. The work of the association “with the goal to *induce increased returns and an increased value on our grain and seed cultivation* is without doubt the best measure to ward off the disaster that threatens the agriculture of this era and not least our country.”²⁵ The experiments conducted at Svalöf and in other countries had shown that the use of refined seeds increased yield with “not just one but many barrels of grain per acre at the same time as the improved quality of the good ensures it a higher sale price”. This increased production would then be exported to other countries, as explained in the association’s objective statement of 1886: with improved seeds “grain produced in our land will become of great value to the continent”.²⁶ This would lead to better conditions for Swedish farmers – without the word tariff having been mentioned even once. By performing such a critical task, the association trusted the farmers to be wise enough to “support and encourage her pursuits through becoming members and through that make it evident that they realize the importance of such an association and work for the common good.”²⁷

The contribution of the association in potentially alleviating the agrarian crisis was acknowledged by renowned scientist and later Member of Parliament, Christian Lovén, in a lecture at a meeting at the Royal Academy of Agriculture in 1887. The topic of the lecture was measures for lowering the costs of grain producers and ensuring enough sales for their harvests domestically and abroad. The low price on grain, he deduced, was partly due to the low world market price. But that was only part of the answer. The fact that the consumers on the other side of the production chain had considerably raised their demands on the quality of the grain was just as important. Access to the grain of faraway lands meant that the modern mills of the country would “not accept the goods that were willingly received at the small mills of the time of our fathers, because no other alternative was present”. The same went for the breweries. Lovén had pointed out this already in the beginning of 1886. “Fortunately”, he now stated,

since then very powerful, and as I hope successful, measures have been taken to remedy this evil, among which I here will mention only...the Swedish Seed Association...whose activity for the improvement of the Swedish seed and thus the Swedish grain has been very extensive and has raised lively interest. To the degree that this activity is allowed to

²⁵ “Sydsvenska Föreningens för odling och förädling af utsäde årsredovising 1886”, Bilaga, p. 2.

²⁶ ”Sydsvenska Föreningens för odling och förädling af utsäde årsredovising 1886”, p. 7.

²⁷ “Sydsvenska Föreningens för odling och förädling af utsäde årsredovising 1886”, Bilaga, pp. 2-3.

continue, while sounder views on the necessity to use only good and pure seeds, and to carefully clean and otherwise handle the harvest in the best possible way, spread over the entire nation, surely the difficulties in selling due to the lower quality of the good will eventually lessen....²⁸

One important part of the context of the creation of the Seed Association was thus low competitiveness on the grain sold by Swedish farmers. The association identified a problem here: due to lack of resources in terms of scientific training, time, and money on local or individual level no improvement of the grains could be carried out by the producers themselves. By promising to pool resources from different parts of the country in order to sustain a long-term effort to improve the grain, the association aimed to fill this vacuum and through that alleviate the severe conditions of the producers. Ideally, then, the producers would enter as members of the association, each contributing financially to the creation of better seeds which they would then be able to purchase. Each would therefore contribute to the good of the whole sector.

Financing the Association

The members of the association was to pay an annual membership fee of 5 *kronor* (kr) or a one-time fee of 100 kr for a life-long membership. In order to amass enough funds in order to start activity a “guarantee association” consisting of 32 persons agreed to pay a total sum of 5000 kr in the five years to come. In a letter sent out to farmers in 1887 the association explained the need for improvement of the grain cultivated, and the role it could take in this, and urged the recipient to “both become a member, and urge farmers among your friends and acquaintances” to become members. Given the benefits to the whole sector “the small sacrifice of 5 kr for the individual will be found well-spent money”.²⁹

How small a sacrifice was 5 kr for the individual? A brief look at the prices of a handful of consumer goods in 1887 gives some idea of what an individual farmer had to give up in order to contribute to the common good of the agricultural sector. 5 kr could buy 78 liters of milk, 24 kilos of bread, and 50 bottles of beer.³⁰ In terms of consumption goods for a small farmer it was thus probably not a small sacrifice to make. In comparison with investments in agricultural machinery, however, the membership comes out as quite modest. A drill pulled by two horses, in order to speed up the seeding process on the fields, cost as much as the

²⁸ Lovén (1888), p. 44.

²⁹ “Sydsvenska Föreningens för odling och förädling af utsäde årsredovising 1886”, Supplement B, pp. 3-4.

³⁰ Calculated from prices taken from Ljungberg (1990), pp. 259, 398, 415.

yearly fees of 59 members, and a milk separator 70 members.³¹ In a way, then, the association could argue that adding resources to the plant breeding pool was a comparatively small price to pay for taking part in the advancement of one's own situation. For bigger farms it probably was a minor cost, but for many farmers, especially during an agricultural crisis with falling sale prices, it should have been a far from negligible cost. In pure material terms, it was also not exactly clear what the immediate reward for becoming a member was. The improved seed was to be sold by the Seed Company, and anyone could buy the seeds without being members. The association thus expected the farmers to realize the long-term value of their commitment for the sector as a whole, and thus indirectly to themselves. Whereas the expensive farm equipment mentioned above was an actual physical tool that could immediately be used and exclusively on the fields of its buyer, the pay-off of supporting plant breeding was far less tangible. Implicit in the invitation to join the association was therefore the almost ideological exhortation to support the common good though the individual pay-off seemed far off.

Ideological fervor was indeed one of the ways in which supporters of the association tried to increase its membership base. The famous "Agrarian Prophet" himself, an ideological leader of the small farming movement, PJ Rösiö, as a member of the Seed Association visited Svalöf at the annual membership meeting in the early 1890s. In an article later collected in the manual for small farmers (*Landtmannens Bok*) he praised the associations's activities, urged small farmers to support it and touched upon the need to pool resources in order to solve the common problem:

Every Swedish yeoman, every *truly* patriotic mind, should be content with these strivings to which one should certainly add one's own. We farmers can potentially do great things if we join together what each and everyone can do in this case. The Swedish Seed Association is in many directions of our culture, a force around which we individuals should, as small but significant factors, constantly orbit with our contributions, a force that perhaps only through this will be powerful enough.³²

This ideological fervor, however, seems to have been insufficient to generate enough support from individuals. At the annual meeting in 1888 Hjalmar Nathorst, professor and director of the Agricultural Institute at Alnarp, held a lecture titled *The Need For Wider Support From the Public For the Continual Development of the Association*. Despite the fact that the first challenges had been successfully met, the association's financial reckonings for the last year once more showed a large loss. The association had represented the Swedish

³¹ See Ljungberg (1990), pp. 306-308.

³² Rösiö (1895), p. 50.

agricultural sector at the grain exhibition held in Copenhagen in 1888, thus showing the outer world that Swedish grain could potentially be of interest for which “the farming public should be thankful to the association”.³³ With the financial loss of the two previous years, it seemed the farmers of the nation had failed to live up to their part of the process. Given the contributions made by the association and its financial problems Nathorst was annoyed at the farmers:

It is...not more than just and fair that the association should be able to count on economic and moral support from the public whose interests it exclusively aims to serve, in other words if she expects that *the farmers more diligent than before join as members and give her work the attention and encouragement it without doubt deserve*.³⁴

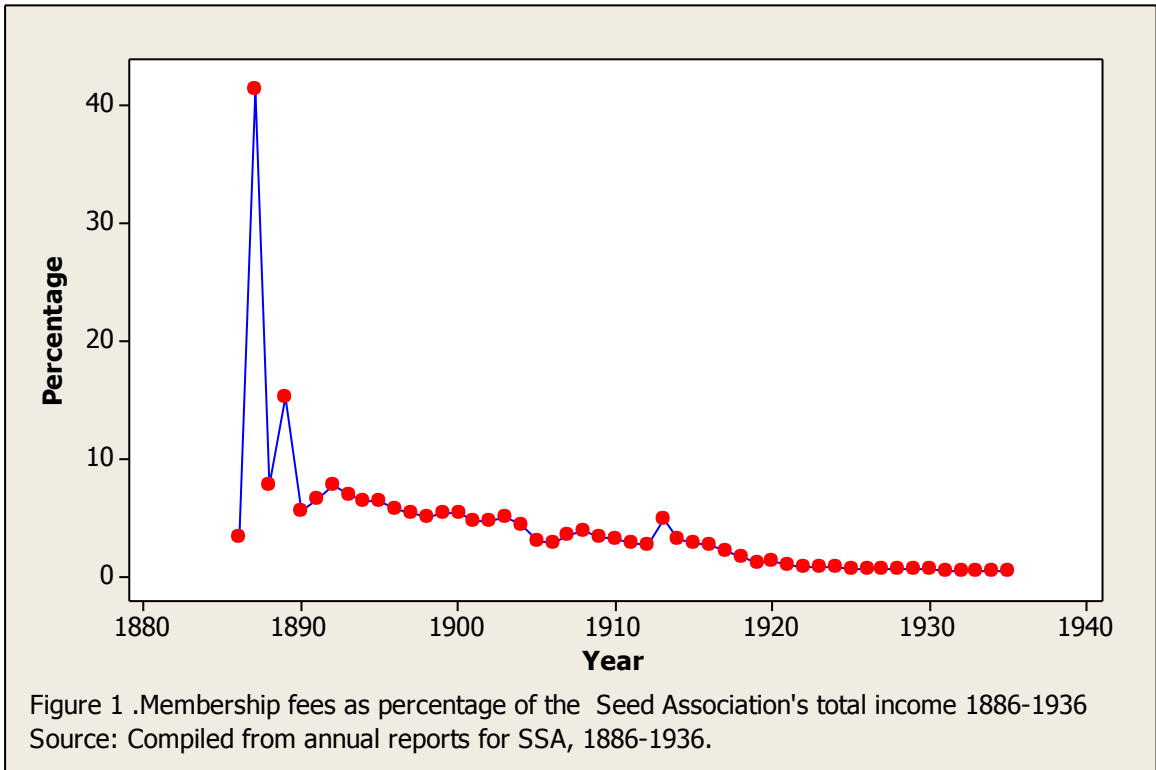
The financial situation of the past years was bad enough, but the association needed funds not only to make both ends meet but also in order to expand its activities and go deeper into the mechanisms underlying plant breeding. This would require the construction of more buildings for specific purposes, and furnishing them with expensive scientific equipment. If membership fees were the only source of income, then the future expansion of the association seemed threatened.

But what about funding from centralized authorities and organizations? If one studies the statutes of the founding of the association in 1886, it is evident that at least some of the founders had doubts that the association could be entirely funded by membership fees and that the guarantee association was necessary until “public support can be won or the financial position of the association renders it superfluous”.³⁵ A look at the income derived from membership fees, shown below as percentage of total income 1886-1936, confirms that the association, with exception for its second year when it also sustained a large financial loss, was never even close to finance its operations through relying on its members.

³³ ”Allmänna Svenska Utsädesföreningens årsredovisning för 1887”, p.75.

³⁴ ”Allmänna Svenska Utsädesföreningens årsredovisning för 1887”, p.75.

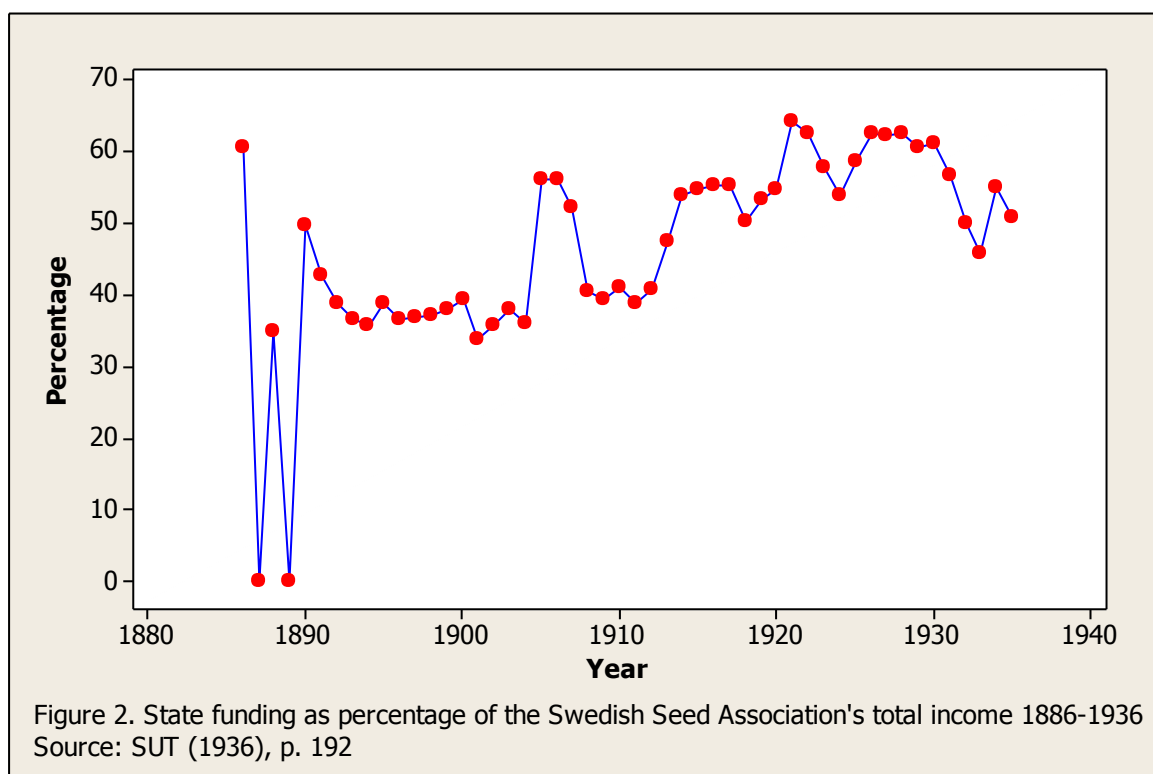
³⁵ . “Sydsvenska Föreningens för odling och förädling af utsäde årsredovising 1886”, Supplement A, p 5.



As the size of the association’s budget, as will be described below, increased thanks to funding from public authorities, the importance of the membership fees dwindled. The mass support from individuals that was the dream of the founders never appeared. One explanation for this might be a case of free riding: there was no direct material reason to pay the fee, since one could buy the improved seeds anyway. Another explanation might be that the tariff on grain enacted in 1888 took the edge from the felt need to rally behind the common cause of grain improvement. It is interesting to speculate about whether plant breeding could ever have become something of a mass movement if the tariff had never been enacted and the association had managed to stage a successful advertisement campaign in collaboration with agrarian societies and government organizations. As it was, public funding instead was the way forward.

In dealing with the authorities that was to fund the association, the members took on a different value than the financial one in illustrating the connection to actual Swedish farmers. Having farmers, even if they were too few, from different regions as members had a very important symbolic value in making it possible for the association to claim to be an all-encompassing national affair. This proved to be very useful when applying for grants from public institutions. In the appliance for state support in 1887, the association emphasized its intention to bring all of Sweden into its activity, and that “farmers from different parts of the

country have entered as members of the association”.³⁶ The involvement of the Danish state in plant breeding – funding three separate plant breeding organizations, one for root-crops, one for barley, and one for wheat - was held out as both a virtuous and threatening example. Denmark was pointed out as Sweden’s “worst competitor on the world market when it comes to agricultural products”, and the Swedish state should follow the example of the Danish state and fund the association’s activities.³⁷ The association applied for 10 000 kr but received only 5000 kr the first year. Another grant of twice that amount was given two years later. Since 1890 a permanent grant was paid out, and the state henceforth became the financial backbone of the association. The graph belows shows the percentual proportion of the association’s income that consisted of state grants.



Adjusting itself to the institutional and geographical situation of Sweden, the association aimed to breed plants for different regions with different soil and climatic characteristics. Later a system of substations in different regions was therefore implemented in which plant types could be tested in different regions, and in close contact with the persons and institutions involved regionally in agriculture. This regional and local emphasis meant that the

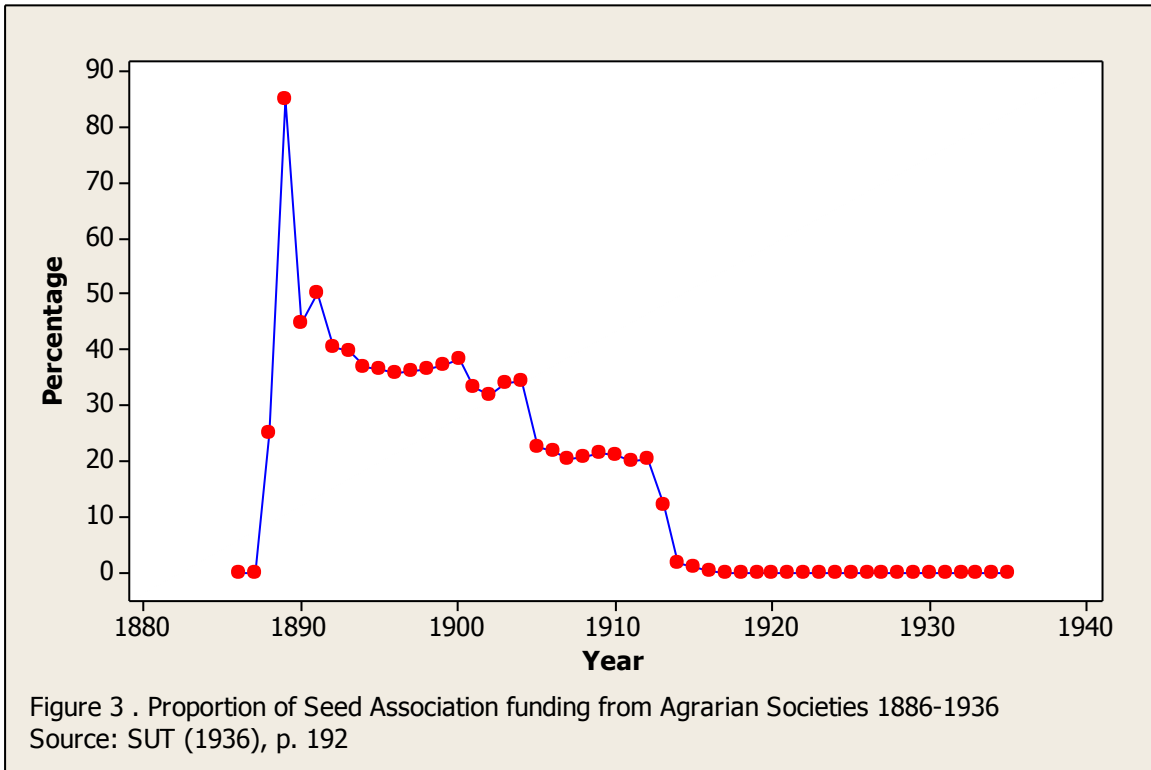
³⁶ ”Allmänna Svenska Utsädesföreningens årsredovisning för 1887”, p. 22.

³⁷ ”Allmänna Svenska Utsädesföreningens årsredovisning för 1887”, p. 23.

Agrarian Societies of the different counties potentially had an interest in the betterment of the plants cultivated within their territory. Contact was initiated with the Agricultural Societies, and each society was promised one representative in the board of the association per 500 kr they paid a year.³⁸ The appeal was successful and considerable sums were paid to the association by Agricultural Societies throughout Sweden, even surpassing the state grant in 1896. It seems, then, that there was considerable interest among these regional organizations around the country, and several of them also contacted the state for support in order to create regional substations. This system of an all-covering network of stations and breeding institutes, from Luleå established 1906 in the North to the main institute in Skåne, meant that the association could lay claim to represent the interest of the entire nation – something that was very useful in the dispute with Weibulls on the continual public character of the association. Of special importance in this system was the station for Mid-Swedish conditions created in 1897 at the Institute of Agrarian Science at Ultuna, which introduced the same long-lasting cooperation between institutional agrarian science and plant breeding as was later established with the University of Lund.

By managing to anchor itself on the regional level, the Seed Association was able to receive a large portion of its income from Agricultural Societies around Sweden. Figure 2 below shows the percentual share of the association's total income 1886-1936 that consisted of grants from the country's Agricultural Societies.

³⁸ SUT (1936), p. 184.



The graph shows that the Agrarian Societies were very important for the first decades of the Seed Association’s first decades, before dwindling in the 1910s possibly as a consequence of more detailed division of labor between state and Agrarian Societies.

With this background I will now turn in more detail to how improvement of wheat was conducted, and the roles of the different actors involved.

Baking the Bread of the Industrial World

As Sweden industrialized it also went through a number of shifts in consumption patterns. For agriculture one important such shift was the increased preference among consumers for bread made from wheat. This gave incentives for farmers to increase their wheat cultivation in a country in which most wheat had been imported, causing a severe competition between domestic producers and imports.

The introduction of the imported British Squarehead wheat gave farmers the opportunity not to use seed with genetic material from the old Swedish land wheat stock. Squarehead wheat became increasingly popular due to its higher yield, especially in Skåne. It is easy to understand the market incentive for adopting such a high-yielding seed: higher yield gives a larger volume of harvest, which means more to sell on the market; productivity goes up for

the individual farmer and gets added to the general productivity increase duly noted by the Agrarian Societies and reported in the national statistics. This should be the stuff of economic development: the wish to sell more on the market gives rise to adopting innovations which translates into higher productivity. The problem, in this case, was the nature of the product and the role it was supposed to play in the increasingly industrialized world. For reasons that were obsessively explored during the decades to come, baking bread on a large scale required the plants used as input to have the right chemical build-up, primarily a high level of protein. The high-yielding seed that the farmers wanted to use because it gave them larger harvests did not have the properties valued by the mills and the bakeries, simply because they were not suitable for producing bread, who preferred to import wheat with the wanted properties instead.

The connection between protein – or “nitrogen compounds” as it was primarily called at this time– and suitability for baking was clear in the 1890s when organized plant breeding was starting to stake out its role in a more globalized agricultural world. The high-yielding Squarehead types increasingly favored by Swedish farmers were low on protein, which meant that the mills did not want to buy it but preferred to import “harder” wheat from Russia, Hungary, and North America. In 1891 the Seed Association reported that a modern mill in order to produce fine flour preferred to mix wheat of different types from different countries, only twenty percent of which was Swedish while the rest was made up of an even mix of Russian and German wheat.³⁹ At least one attempt was made by one of the larger mills in the middle regions of Sweden to internalize the supply of suitable wheat. Search in order to find an “universal wheat” and cultivation projects to grow Hungarian and Russian wheat on Swedish soil were carried out by the mill and abandoned due to scant results. What were required to solve this conflict between growers and processors were the tools of science. Denmark, quite often a source of Swedish inspiration both for agricultural science and agricultural organization, had faced a similar problem after the spread of the Squarehead wheat. Here, according to the Seed Association, experimental fields with wheat types of different protein content – the so-called “*Hvedeudvalget*” – was set up “to solve the conflict” with representatives from both sides.⁴⁰ The details of the Danish case fall out of the scope of this study, but it seems highly unlikely that farmers and mills could harmonize their efforts into systematic research in the frictionless way described by the Seed Association. In any

³⁹SUT (1891), p. 137.

⁴⁰ SUT (1891), p. 137.

case, the Danish plant breeding system had started to falter within a few years of its creation, though good results in recent time suggested an expansion of their activity. Germany was another country where the conflict between the mills and the farmers who wanted to grow high-yielding Squarehead wheat caused problem. If the consuming public wanted bread, and the bread was supplied to them by the bakeries and the mills with farmers at the bottom of the production chain, then should not pressure be put on the farmers to grow wheat types with higher protein levels?

Here the Seed Association, seeing a potential function for them to fill, took the side of the farmers. They pointed out two important things. First that the types with higher protein levels had lower yields, translating into higher productivity costs per volume unit. Second that more protein in the wheat required taking up more nitrogen from the soil, which depleted it from nutrients much faster. As long as the higher production cost, and the faster rate of soil depletion was not compensated by a higher price “the farmer cannot agree to this”.⁴¹ The solution was to apply science in order to achieve *both* higher yield and high protein levels:

We are able to bear hope to accomplish larger harvests, without fearing for worse quality. The betterment of both can of course go hand in hand through conscientious plant breeding.⁴²

As was mentioned above, farmers themselves did not engage in consciously changing their product to be more competitive on the market, and the Seed Association essentially saw it as their task to perform what the farmers themselves could not do. The farmers should understand that bettering their product through the activities of the Seed Association were in their own interest, and not simply a way of adjusting to the pressure of the often unpopular mills and bakeries:

Without...giving in to the interests of the milling industry and the bakers, the Swedish farmer should arrange his wheat cultivation in the way most suitable to his economy in that that he, notwithstanding the absolute nitrogen level, aims for higher yield simultaneously with higher quality. To show the right path, in this matter, is the purpose of the wheat experiments conducted at Svalöf...⁴³

This conflict was not just a economic and social problem, but also a scientific one. Surely, the phenomena of the quarrel with farmers on one side and millers and bakers on the other must have its roots in the molecular level? The question why the high-yielding wheat types

⁴¹ SUT (1891), p. 138.

⁴² SUT (1891), p. 138.

⁴³ SUT (1891), p. 139

resulted in poor flour was, according to the Seed Association in 1891, “not fully answered”.⁴⁴ If scientists were to solve the conflict they had to increase their knowledge about the chemical process taking place beneath the visible phenomena of quarreling farmer, millers and bakers. Chemical investigations had revealed that gluten was more complex than previously believed and consisted of several different types of protein substances. This meant that one could simply not measure the amount of gluten and then expect high levels to result in high degree of baking capability and vice versa. Some gluten compounds meant better baking capability and some worse, through adding or subtracting adhesiveness. Unfortunately, all the chemical methods available at the time was not reliable enough to be able to be of “any practical value”.⁴⁵

During the decades to come the methods of chemical analysis became more advanced, allowing more systematic mapping of the protein composition of different samples. For the time being, however, the breeders had to undertake a program of mediating in the interest conflict between farmers and bakers with the somewhat coarse methods of test baking. To do this “demanded considerable practice, and it is therefore advisable to initially enlist the help of a baker, through which large amounts of fruitless experiments can be avoided.”⁴⁶

But if the old Swedish country wheat types in general had the advantages of having higher protein levels, and better resistance to low temperatures, and the Squarehead wheat types had higher yield, could not the best of both be combined? Although the exact principles of passing hereditary traits on through generations were not known, it had been observed that Squarehead wheat had spontaneously mixed with country wheat.⁴⁷ Refined squarehead lines also proved to be vulnerable for natural selection due to its vulnerability for low temperature, and thus had a tendency to “degenerate”.⁴⁸ The aim of the Seed Association increasingly became to combine the best of both main types. Interest in cross-breeding was increasing not just in Sweden, but also internationally with several contributions leading up to the rediscovery of the laws of Mendelian inheritance in 1900.⁴⁹ The decades to come spawned a great number of new types that were marketed to the Swedish farmers, some of them only for a very brief time. The large number of introduced types, and the fact that many of them were only sold for a brief period before being terminated, suggests that the process of

⁴⁴ SUT (1891), p. 145.

⁴⁵ SUT (1891), p. 146.

⁴⁶ SUT (1891), p. 149.

⁴⁷ SUT (1891), p. 137.

⁴⁸ SUT (1936), p. 338.

⁴⁹ Widmalm (1999), pp. 134-135.

“modernizing” the genetic stock of Swedish wheat was to a large degree a trial-and-error process. Clearly some types were simply not desired by farmers, or failed to be of any significant use.

The hereditary roots of all the desired qualities – winter-hardiness, yield and baking capability being the most important – lay hidden beneath the visible phenomena. The test grinding and baking described above were coarse methods. More advanced methods were necessary in order to reach beneath the visible phenomena, and gather more detailed and refined information to serve as guidelines for more effective plant-breeding. One limiting factor for this, as mentioned above, was the available methods and instruments for chemical analysis. With advances in chemical science the possibilities increased. The key for utilizing these new possibilities lay in the construction of laboratories. Laboratories, staffed by trained scientists, are notoriously expensive giving rise to the problem of financing the activity on an entirely different scale. A special laboratory for the purpose of measuring the protein level in grain was built in 1908, but the Seed Association did not have enough expertise to carry out the chemical analysis themselves; instead this part of the Seed Association’s activity was carried on in cooperation with the government organization Bureau of Seed Testing. Following increased state funding the Seed Association could hire its own chemist in 1914, and in the years to come the ambition was broadened to also include the chemical foundations of winter-hardiness.⁵⁰

The importance of chemical analysis lay in the guidance it provided for plant breeding. New breeding material – new grain types with their specific set of properties – were routinely collected and brought to Svalöf. The utility of such new types could be assessed in terms of macro properties, such as yield in terms of weight or resistance when exposed to low temperatures. But through chemical analysis the level of protein, the types of proteins present, and other information could be assessed and transformed into useful data for guiding plant breeding.⁵¹ For instance, a high level of gluten in a particular wheat type would indicate its suitability to be a component in continued plant breeding, leading to a decision to attempt to add its traits to the pool of useful traits. More systematic and effective analysis, for instance investigations into which chemical properties were of special importance in increasing suitability of the grain in baking bread, and in consequence more detailed guidelines for breeding activity, however, had to wait until the 1920s and the allocation of more resources –

⁵⁰ SUT (1936), p. 224.

⁵¹ SUT (1936), pp.224-225.

resources that were released after a whole array of mechanisms had been put in motion by the pressure of international competition.

Facing international competition

World War I had effectively forced Sweden into autarchy. When trade resumed after the end of the war, the grain from abroad again became an alternative to the types grown by domestic farmers. This included the North American wheat. The United States and Canada had been cut off from their European markets during the war, but had been able to continue to develop their agriculture, supported by government intervention and increasing cooperation, while war ravaged the lands of continental Europe. Swedish farmers after the war hence found themselves pitted against a far more competitive rival than before trade ended. Once more mills and bakeries favored the grain from North America, but they had become even more willing to pay a higher price for the imported wheat due to its high baking capability. The increased demand and the tariff raised the cost of American and Canadian wheat to 20 percent higher than Swedish wheat, but the bakers were still willing to pay this higher price because of the superior bread they could produce with it.⁵² Since fewer mills and bakeries purchased domestic wheat, price on these fell to the dismay of their producers. Professor Nilsson-Ehle, head of the Seed Association, in 1923 explained to the Swedish farmer in the agricultural journal *Landtmannen* that the reason for the harder conditions compared with before the war, lay in the fact that the quality of the imported wheat was much better than before.⁵³ The cultivation of superior wheat types, especially Manitoba – “the finest wheat in the world”⁵⁴ – had increased considerable during the years. While the war lasted Sweden was largely isolated from competition of these types, but now, with peace and trade restored imports could resume once more – this time after foreign wheat had undergone a clear general improvement making them a severely greater threat to domestic interests. “Our wheat” Åke Åkerman at the Seed Association concluded in 1923, “is thus today forced to endure much harder competition with American wheat and flour of the highest quality than before the war, and this must naturally have an effect on the price level.”⁵⁵

⁵² SUT(1923), p. 293.

⁵³ Nilsson-Ehle (1923), p.

⁵⁴ SUT (1923), p. 293.

⁵⁵ SUT (1923), p. 294.

Restrictions on trade was called for, since, it was argued, the success of Swedish plant breeding had made Swedish wheat at least good enough to be of industrial use. Import of American wheat was dismissed as “luxury import” in the end harmful for both consumers and producers.⁵⁶ Similar calls were issued from different parts of the land. And indeed, in 1923 the mills agreed, in part as an expression of belief in plant breeding agreed to use 50 percent domestic grain in their grinding, expecting the other half consisting of imported American wheat to be enough to sustain a high degree of baking capability.⁵⁷ This regulation in essence meant that the Seed Association now had a common cause with the milling industry in increasing baking capability in domestic grain.

Entry of Oligopoly

While the plant breeders were exploring the principles of inheritance, and churning out new seed types, many of them with very limited success, the position of the mills in the chain from field to end consumer had strengthened, though possibly undermined by the appearance of mills owned by consumer and agricultural cooperatives. In 1913, as was mentioned above the owners of the mills had entered into a cartel in order to ensure high profits. Mills were important not just for their market position. With market position came resources and concentration enough to finance laboratories in order to use science to better the quality of the grain. The disruption in trade of World War I had forced the mills to consider the molecular roots of baking capability more in detail. Special chemists were hired for the task, by two large mills, Saltsjöqvarn and Malmö Stora Valskvarn, and laboratories constructed.⁵⁸ Similar developments were present in the brewery industry.

The Seed Association initially did not have a special laboratory for studying the roots of increased suitability for making bread. However, following the regulation, the mills and the plant breeders had a common interest in providing reliable data for better precision in breeding for higher degree of baking capability. Therefore the mills agreed to perform analysis of the baking capabilities of different grain types in their own laboratories. In 1936 the Seed Association in their historical account, on occasion of the association’s 50 year jubilee, declared their gratitude to the largest mills for their assistance in this matter:

⁵⁶ SUT (1923), p. 294.

⁵⁷ ”Kvarnföreningen 50 år”, p. 62.

⁵⁸ ”Kvarnföreningen 50 år”, p. 61.

With regard to analysis of baking capability these were carried out in the laboratories of some of the larger mills, and the association is greatly indebted to the leading men of Malmö Stora Valskvarn, Saltsjöqvarn the Tre Kronor mill in Stockholm, Kalmar Ångkvarn and others for the willingness they showed to carry out these analyses. Through these and other analysis later carried out at the mills, the wheat specialist of the association and its chemist also entered into a very valuable cooperation with the chemists of these mill enterprises...a cooperation which has been lasting since this and subsequently been expanded.⁵⁹

But the mills and breweries also helped with financing the laboratories at the Seed Association itself. Nilson-Ehle in 1930 acknowledged the possibilities opened up through these more advanced laboratories, and its importance for Swedish agriculture as well as the part played by industries:

The association thus has the pleasure to inform the farmers of the nation, that the important and in significance growing *quality refinement* in the grain types and other plant types have taken another step forward through the considerably better possibilities for the assessment of quality in the laboratories at Svalöf, that has been accomplished thanks to participation with interest and support from the mill and brewery industries. In this way a very extensive modernization and refurbishment of the laboratories in the Association's research building at Svalöf has been undertaken and a great number of new and useful devices...acquired, through which needed analyses can be performed in a considerably more complete way than before.⁶⁰

Now all the many different wheat types could be evaluated and classified according to their baking capabilities, which gave more information both to farmers who were to chose which seeds to use and to millers and bakers who were to process it. Such new analysis methods also gave useful guidelines for plant breeding, since new strains could be more readily assessed.⁶¹ This also provided an scientific infrastructure that could convince politicians in the early 1930s, when more rigorous regulations was enacted that Swedish grain could become good enough for industrial use even if imports were reduced sharply. As the regulations were enacted, the state became increasingly supportive of the cereal laboratory at the Seed Association. In this way the results of and the belief in future results of plant breeding became an integral part of how regulations were constructed.

Conclusion

This paper dealt with the question how improvement in quality of a good can be accomplished despite a dispersed market structure. In the case of Swedish plant breeding, a special organization was intended to pool resources by individual producers and seek support from

⁵⁹ SUT (1936), p. 228.

⁶⁰ Nilson-Ehle- SUT (1931), p. 4.

⁶¹ SUT (1936), 229.

public authorities. Lack of support by individuals, but more support from the state and initially from the Agrarian Societies led to a solution in which all tax-paying Swedes were essentially forced to become members thus solving free rider problem. The oligopolistic mill sector, indeed individual mills, had enough scale to more readily initiate scientific activity in order to improve the grain. But it did not do this out of its will: first it was forced to do so due to the fall in trade cause by World War I, and later by regulations imposed by the state in cooperation with representatives of farming interests. Returning to the Schumpeterian view, then, we would say that the progress made in plant breeding in Sweden was not a clear-cut case, despite the fact that the milling industry in the 1920s financed the Seed Association's laboratories, of spill-over from an oligopolistic sector to a competitive one. Rather, the competitive sector organized politically and managed to create regulations which induced the oligopolistic sector to transform part of its monopolistic rent to the improvement of the agricultural goods.

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