WHEAT BREEDING IN GERMANY, ASSISTED BY MODERN EQUIPMENT AND ASPECTS OF TOMORROW

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INTRODUCTION

This paper discusses the procedures, aims and future of wheat breeding. Some economic aspects and the need for suitable technical equipment for effective work are also discussed.

WHEAT BREEDING IN GERMANY

(a) Breeding procedures

Breeding is carried out in a predominantly classical procedure. After crossing there are extensive single plant selections taken at the F2 stage. These are grown as F3 single rows which produce sufficient seed, from those meeting the rigid selection criteria, to grow small, unrepeated plots in the F4 generation. Replicated, randomised yield trials are carried out at F5; the earliest possible stage. A maintenance program is established at F5 and strict pedigree methods applied. From this stage yield plot trials continue in parallel with the maintenance program. A homogeneous variety with adequate seed supply, at least 50 kg, can be achieved from the F8 generation.

A variety is usually submitted for official testing around F10. Varietal characteristics described at this stage, however minor, can be crucial to establish distinction from the large number of other entries. Absolute homogeneity is required for the first year of official testing. Both seed and single ears have to be supplied to the official testing body, the Bundessortenamt, who, upon detection of heterogeneity, may reject the whole variety or at least require the first year's testing to be repeated.

(b) Breeding aims

Yield is paramount, followed by quality and disease resistance. Sixty percent of wheat on the western market is used for animal feed so consequently, yield is the main breeding aim. The over-production of wheat in these markets however results in lower prices and a demand for higher quality for human consumption.

The protein content becomes ever more important in the feed market, as wheat competes more favourably now with low protein energy substitutes. Baking quality is strictly monitored. Besides the traditional rapid mix test, the flour yield, water retention, and dough quality are included in the quality attributes for breeding. Biscuit wheats are becoming more important as European biscuit consumption is higher than in Germany. Noodle wheat has a very special market for egg noodles nationally and internationally.

Disease resistance may be bred for either vertically (race resistance) or horizontally (tolerance). A combination of both is desirable. To establish the resistance type of new lines early, one has adopted new techniques. e.g. leaf infection of young plants, (mildew a.o.) and electrophoresis to find resistance and quality carrying bands. Soon practical genetic markers will be used in preselection.

Additional breeding objectives may include varieties for reduced or non-chemical farming, the use of bio and genetic technology and hybridisation.

Chemical free and/or low input farming requests breeding adapt to its demands. High yielding varieties often prove the best even with reduced input. The magic word 'sustainable' applies to intensive and

extensive agriculture. Trials always contain untreated controls. Often the overall best line will out-perform both the treated and the untreated controls. A non-resistant line however may sometimes top the mean yield in the treated comparison, since it did not seem to have spent any effort coping with the disease. Defence mechanisms, even in natural resistance, cost certain energies, which reduce yield potential.

Breeding using bio- and gene technology (starting with a cell and a culture) are less exploitable to wheat breeding than many other crops. They are possible yet far more difficult to apply to wheat than to barley. These techniques will be used more in the future as they allow certain resistances and pure lines to be developed quicker. Genetic marking for specific selection and diversification of certain characteristics in early generations is a rapidly developing technique. We hope breeders gets practicable access to this development. Specific gene introduction is still in its infancy, having no practical consequences as yet, but is monitored by the breeders.

There is some resumption of effort to breed hybrid wheats. The ambition to make a big step forward in yield and to force farmers into buying seed is still behind all efforts for hybrid wheat breeding. Two methods are pursued: CMS based male sterility with restorers and gametocytes. There has been no real break-through in the latter, as yet. Some hybrid varieties have been produced but delivery of seed at a reasonable price is still not possible. The hybrid effect in self pollinating crops does not seem as dramatic as in cross pollinating crops.

(c) Genetic resources available to breeders

These have increased due to the amalgamation of east and west Germany. Each breeding station has its own gene pool however European private plant breeders and institutions exchange resources quite freely for crossing and do exchange trials. Cooperation with institutes internationally contributes vitally.

Testing procedures in Germany

New varieties are registered and protected after successfully passing three years of official testing for agronomic value, homogeneity and novelty. Tests are the responsibility of the Bundessortenamt, federal variety bureau. Breeders are involved in the first official year. They have to supply data on each line before the first test year. Additional state based testing is carried out after a variety is accepted by the Bundessortenamt, taking 2-3 years before a recommendation is made by the regional Agriculture Department.

Entries in the official tests decrease as they progress to more advanced stages. Wheat is the most important crop bred. Winter wheat has 70-80 new applications per year, 30-35 continue to second year, 10-15 go into third year, 4-8 get plant variety rights protection. One or two varieties only achieve mentionable success. About 60 winter wheats and about 15 spring wheats and a few Durum wheats are presently registered.

Economic structure of plant breeding in Germany

Plant breeders rights are the incentive for plant breeding. Plant breeding is a work sector in itself and is the base of the economy in agricultural plant production. The essential factors which render breeding economic originated in Germany. The first plant breeders rights legislation in the world had the premise that private investment into plant breeding took place and could pay for itself. The legislation is drafted to allow new varieties to be used for crossing by all breeders. This is a basic difference to the way patents for technology are handled and gives free access to much needed gene pools. Continuous legislative updates bind it into the international organisation, UPOV. Strict seed certification legislation also originated in Germany, to assure a continuous supply of quality seed.

Germany has the greatest extent of private plant breeding.

Nowhere else are so many breeding activities carried out in independent, medium sized, private plant breeding stations. About 30 private stations are active in wheat breeding, many for generations. Few stations are run by large companies and multi-national organisations.

Small stations in diverse locations under diverse climatic and soil conditions allow a quick response to regional agricultural demands. The competition is complemented by cooperation, as many plant breeders share a marketing cooperative. Too much concentration of breeding in a large organisation is felt to suppress smaller self contained, independent plant breeders and should be closely monitored, as:

- no other system is more economic in costs and benefit.

- no structure is more flexible and affordable.

- no other structure avoids a more live or kill situation.

- no other structure cares more capably for minor crops.

Big monetary input to solve plant breeding problems resulted worldwide in a takeover of smaller private breeding stations by larger companies. However the breeding methods involved and results obtained did not differ much between the big or smaller enterprises. A number of large companies decided to drop their plant breeding activities after only a few years work. The economic structure of large organisations can endanger their continuity and resolve to address the needs of the farmer. There is not only one way to approach plant breeding so lets see who is really going to roll their sleeves up in future.

Research for plant breeding

Basic research work carried out at universities and government institutions is sponsored heavily by private plant breeders. A Research Association for Plant Breeders, GFP, was founded by breeders and carries out basic research to assist in practical breeding work and in the introduction of new biotechnology.

Future wheat breeding will demand new approaches, which are yet to be defined. The rapid exchange of wheat varieties in Germany, their different uses in the east and west and environmental issues will provide the incentive for development. Plant breeding alone however will not be able to solve all problems. Responsible plant protection chemicals are needed to ensure food and feed production. Wheat is capable of producing protein, but principally starch. Wheat starch as a substitute for some plastics is conceivable. It is also feasible to grown wheat as raw material to substitute for other natural resources. One example is packaging materials, which would have inherent recycling properties. Wheat has a key role in crop rotations as its yield capacity can be adapted to our environment. Intensive plant production gives a better relation between O_2 and CO_2 - although is not justification for further forest clearing! To make this relation clear to people outside the agricultural field is hard, but we should try.

Research technology

Technical equipment is required to substitute for manual tasks as suitable labour is both expensive and difficult to attract. Decreasing cross margins demand procedures delivering significant results. With suitable equipment it is now possible in one hour to sow 500 and harvest 120 plots. The reliability of the machines has increased considerably. However, old machines are still operating, prohibiting new machines proving their advantageous development. In the interest of accurate trials, work capacity, occupational health and safety and comfort, the researching technician must be provided with best equipment. Hege pursues ISO 9000/9001 to establish these claims.

The range of equipment available includes: Cone seeders with highly sophisticated distribution systems and magazine feeding, Pneumatic precision seeders and fertiliser applicators,

Sprayers and spray testing equipment for correct application, High capacity tool carriers for controlled traffic cropping

Laboratory equipment, seed cleaners and labeling equipment,

The range of HEGE plot harvesters is the most adaptable and transportable on the market. A forage harvester is included.

CONCLUSION

Plant breeding is individual work, basically the same worldwide with the same objectives. Breeders need the economic environment and best equipment for their work. Let's rely less on the computer screen and more on field observations. For the total green approach, see below, for details, see the authors.

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