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TAB

Genetic engineering, breeding and biodiversity

Summary

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SUMMARY

The TA-project »Genetic engineering and breeding from the viewpoint of biodiversity in agriculture« is based on a recommendation by the Committee for Nutrition, Agriculture and Forestry of the German Parliament and was approved in Autumn 1996 by the Committee for Education, Science, Research, Technology and Technology Assessment. The investigation area was limited to the field of plant breeding and – as far as possible – was restricted to the agricultural sector in Germany, taking into account European framework conditions.

The goal of the TA-project was to investigate what negative influences the use of genetic engineering in plant breeding can have on biodiversity, what contributions breeding and genetic engineering can make to conserving biodiversity and finally, what potentials can be derived for policy-making. It became apparent that a restricted, technology-centred perspective is not adequate for this theme. Particularly on the issue of potentials for conserving phytogenetic resources and biodiversity in general it seemed necessary to expand the theme in order to cover the significance of genetic engineering and breeding in the overall context.

On the other hand, because of the wide range of interrelating contexts involved, it was necessary to restrict the scope of themes to undergo in-depth processing. The report focuses on the description of impact chains which the use of new plant varieties in agriculture could have on biodiversity and the presentation and discussion of the potentials for conserving biological diversity, particularly phytogenetic resources.

This summary gives a general description of the main findings of the investigations and also the potentials for political action according to the subject area in general form (paragraphs in bold type); a detailed list of the options for action and a description according to policy areas including indications of responsibilities and addressees, application status to date and, where appropriate, the possible horizon for implementation, are given in the last chapter of the report.

A WORD TO BEGIN WITH

Modern agriculture has made a considerable contribution to reducing the biodiversity of many crops and wild plants in Germany through intensification, rationalisation, specialisation and concentration of production. Impacts on biodiversity have in particular been generated by changes in fertilisation, plant

protection, rotation and land reallocation and consolidation. Plant breeding and modern plant varieties are all part of the changed agricultural production system and their impact on biodiversity is more of an indirect one. The results of the TA-project lead to the conclusion that in Germany and Central Europe the use of genetic engineering procedures in plant breeding will not have a specific, significantly negative influence on biodiversity compared to conventional breeding practices in the short to medium term. On the other hand, however, genetically manipulated plant breeding will not make any significant contribution to conserving or extending phytogenetic resources. As the impact chains which are related to the introduction of new varieties and which could lead to the loss of biodiversity and phytogenetic resources have not yet been fully investigated scientifically, and are not fully understood, they should undergo in-depth investigation in future.

If the goal of »conserving biodiversity« is pursued with high priority, then there is in consequence a particular need for action on direct conservation measures. To this end the ex-situ, in-situ and on-farm conservation measures must be improved and developed. As Germany does not yet have a coordinated procedure on the conservation of phytogenetic resources which incorporates all conservation measures, a combined conservation strategy should be developed. This would simultaneously be a major contribution to conserving biodiversity in Germany. In order to implement international agreements at national level and to develop and apply a national strategy to conserve biodiversity (including phytogenetic resources (PGR)), close coordination and cooperation is necessary between the various policy fields and levels affected. Interested and affected societal groups should be incorporated into the national strategy development and implementation process. A matter of central importance for the sustainable conservation of biodiversity is a full-coverage change towards sustainable agriculture, in which the promotion of agricultural diversity and the protection of wild flora and fauna is a major component. The principles of eco-farming which, in contrast to the still predominant conventional farming, involve more extensive and diversified farming practices, could provide significant guides.

Changes in basic framework conditions for agricultural and environmental policy do not make specific conservation measures (as listed below) become superfluous, but their scope and urgency would take on a relative basis. Potential action to be taken is not discussed in this paper as it would extend far beyond the terms of reference of the TA-project.

FOUNDATIONS: BIODIVERSITY AND PHYTOGENETIC RESOURCES

Biodiversity covers three levels: genetic diversity; species diversity and diversity of eco-systems. Of the estimated 10 to 20 million species on Earth only 1.75 million have been scientifically registered. Even less is known about the genetic diversity within the species and populations. Similarly, we have only very incomplete knowledge of the interactions between eco-system diversity on the one hand and genetic and species diversity on the other, and on how the fragmentation, reduction, simplification and degradation of eco-systems impact on biodiversity.

Considerable research efforts are needed at national and international levels in order to register and monitor biological diversity, to understand the interdependence of the three levels and to explore the minimum conditions needed to conserve diversity.

Phytogenetic resources (PGR) cover the entire generative and vegetative reproduction materials of plants with a current or potential value for nutrition, agriculture and forestry. As a result of the intensification of agricultural production, and following a peak in agricultural diversity around the mid 19th century – a substantial proportion of PGR are either jeopardised or lost. The PGR which still exist are insufficiently registered, characterised and evaluated. In particular, knowledge is lacking on the genetic variation of PGR at their natural locations and the minimum population sizes needed to conserve genetic diversity.

National efforts and international coordination and cooperation are therefore called for in order to obtain more in-depth knowledge on PGR and further develop the PGR documentation and information system already initiated. These activities apply both to developing the scientific foundations, to the registration and description of PGR and also to access to the corresponding information.

PLANT BREEDING AND LEGAL REGULATION

For economic reasons, commercial plant breeding concentrates on a few main crop species. Since the fifties, a process of concentration of the cropped species and varieties has taken place, and since the mid eighties a more rapid varietal rotation can be observed. However, the genetic diversity between the species is probably often very low. Whereas large companies dominate the seed market in many industrialised countries, the situation in Germany is characterised by numerous small- and medium-sized breeding companies. Modern biotechnologically and in particular genetically manipulated breeding is a challenge for small- and medium-sized German plant breeding companies because it entails high costs and there is uncertain access to gene constructs because of patenting practises.

The promotion of research in the plant breeding sector should contribute to the sustainable use of phytogenetic resources. In particular, it should contribute to ensuring the future of the varieties on offer at the moment and also to expanding the range of crop species available and the more intense use of PGR. Another goal of research promotion should be to permit small and medium-sized seed breeding companies to carry out their own independent plant breeding in future.

The Variety Protection Law is a private exclusive law providing the legal preconditions for refinancing investments in breeding, whereas the Law on the Trading of Seed governs the trade of seed and seedlings for the protection of the consumer. Varieties that have not been officially licensed may not be traded. The current licensing criteria for new varieties are a constraint to the tradability of many older varieties and of rural and farm varieties and therefore have an unfavourable impact on phytogenetic diversity in cropping. Criticism is levelled not only at the criteria of homogeneity and stability but also at the current practice of defining the criterion of »cultural value for the country« in terms of yield, resistance and quality properties that constrain the diversification of breeding goals and hence of plant varieties.

In view of the relationship between variety protection and patent law it is feared that in future conventional or traditional breeding could be impeded by the new protection elements, that have become necessary, because of the specific requirements of biotechnology and in particular genetic engineering methods. The market for seeds therefore threatens to develop in an undesired direction towards greater concentration and even the monopoly of certain plant species.

The establishment of a system to commercialise provenance seed or phytogenetic resources could be conducive to the conservation of PGR. The legal basis can be created by changing the EU regulations on seed trading and the German seed trading law. It should also be reviewed as to whether by further developing the variety licensing criterion »land improvement value« it would be possible to better promote the use of the PGR. The impacts patenting has on plant breeding in terms of variety protection and the significance of these patents should continue to be monitored.

IMPACTS OF NEW VARIETIES ON BIOLOGICAL DIVERSITY

New varieties can have direct impacts at the inner-varietal level on the (genetic) diversity of licensed and cropped varieties, at the species level on the number of species cropped and at the level of eco-systems on the proportion of each cropped species and the cropping rotation. At the level of an individual farm or of a region – depending on the framework conditions – the selection of a new preferential variety can either result in an expansion (e.g. in the event of a limited supply contract) or a restriction of the cropping areas, consequently lowering or raising the cropping diversity or fundamentally influencing the agro-economic system due to the wider use of extensive farming practises or even land withdrawal. On the basis of existing information it is not plausible to expect modern (conventional or genetically engineered) plant breeding to provide new varieties which are so superior that (in Germany and/or Europe) they will be grown to such an extent on such large areas that this would tangibly restrict species and variety diversity, compared with the present situation. Rather, in the short and medium term and probably also in the long term, other factors such as the agro-policy framework conditions, the global demand for agricultural products or geographical restrictions will be the decisive influences regulating the type and scope of species and varieties cropped.

The indirect impacts of growing new plant varieties can affect both the inter- and intraspecific diversity of the agro-ecosystems (apart from the plants actually cropped) and also the neighbouring eco-systems or those connected via impact chains. Two potential impact paths were analysed in the TA-project: On the one hand, the consequences of changed cropping practises which could result from the characteristics of new varieties and, on the other hand, the potential impacts of the release of new characteristics when plants return to the wild state, as a result of cross-breeding or of horizontal gene transfer. Impacts could particularly influence soil organisms, auxiliary field flora, plant diseases, pests and beneficial insects. However, at the present time the genetically engineered plant varieties in sight are forecast to have a very limited influence on cropping practises and biodiversity, because of the diversity of geographic regions in Central Europe and also because of the large number of other interacting factors. From the transfer (mostly via genetic engineering) of monogenic resistance to diseases and pests it is possible to deduce impact chains concerning the development of resistance which may be of great relevance in practise. If diseases or pests can rapidly overcome resistance, this is disadvantageous for the variety and its cultivation as a crop. The large-scale cropping of transgenic varieties containing Bacillus-thuringiensis (B.t.) – genes is also a threat to the use B.t. of substances in conventional farming and, above all, in eco-farming. Large scale cropping of B.t.

corn and B.t. cotton in the USA will provide first concrete indications of whether resistance management strategies developed to date are adequate and effective.

What impact the introduction of new varieties will have on biodiversity of agro eco-systems and adjacent eco-systems is still not completely understood and intensive investigations are called for. Special attention should be paid to the issue of changes to cropping systems, resistance development and resistance management. Studies should equally cover new conventional and transgenic plant varieties.

Wild spreading of crop plants and vertical and horizontal transfer of genes from one crop to other species are potential effects discussed in the debate on the biological safety of genetic engineering in plant breeding.

The potential for crops to spread wildly can be described, although of course with a certain amount of uncertainty. Despite the phytogenetic relationships between crop plant and weeds, no case is known at the present time of a highly domesticated crop plant becoming established outside agro-ecosystems. Indeed the more intensive the breeding manipulation and consequent removal from the wild plant characteristics, all the lower is the potential for it to spread in the wild. Trials carried out to date to release transgenic plants have not indicated any greater fitness compared with conventional varieties. Knowledge of the parameters which determine ecological fitness is, however, still rudimentary. As conventional and genetically engineered plant breeding select for suitability for cropping in agricultural production systems, it is in principle not probable that new varieties will spread into the wild.

The crossing with related wild plants could result in individual characteristics or groups of characteristics being introduced permanently into wild populations (so-called vertical gene transfer between reproducible crossing partners). It cannot be said in general that there is a specific genetically engineered risk (always compared with corresponding conventional high-yield varieties). Many of the breeding goals aimed at in the longer term which are to be achieved by genetic engineering, such as resistance and tolerance to biotic stress factors or higher capability to enrich with nitrogen, could, however, provide an ecologically relevant advantage for potential recipient plants following vertical gene transfer. In addition to the characteristic properties possible impacts also depend on a number of ecosystem factors. Whether relevant impacts on biodiversity could result from vertical gene transfer cannot be assessed with the present status of knowledge.

Equally poor is the knowledge on horizontal gene transfer, i.e. the non-sexual exchange of genetic information between populations. In contrast to vertical gene transfer, horizontal transfer is a statistically very seldom event (plant-fungus and plant-virus transfers have been proven experimentally). In the context of the present TA-project interest focuses only on whether gene transfer would generate serious risks for biodiversity. In most genes transferred to date, whether for antibiotic, herbicide or insect resistance, such a risk cannot be plausibly described. Concrete problems could possibly result, however, from the use of viral sequences to pre-immunise plants. The constitutive presence of viral genes in crops grown on large areas could promote the genesis of new types of virus, e.g. with a changed host spectrum.

A concrete problem – although primarily an ideological and legal one – which is indirectly significant for biodiversity would arise as a consequence of vertical or horizontal gene transfer: In the long term, ecological agriculture cannot guarantee that its products remain absolutely free of transgenic characteristics. This could at least lead to a loss of confidence and slow down the development of this type of farming, which is particularly conducive to biodiversity.

The licensing evaluations on biological safety should be reviewed as to whether they sufficiently cover the impacts that genetically engineered plant varieties could have on biodiversity. The fundamental knowledge gaps – which it may not in principle be possible to bridge in the foreseeable future – concerning long-term ecological impacts require that long-term parallel research or comprehensive post-licensing monitoring be carried out. These should be attuned or coordinated and combined with the already mentioned fundamental research activities on biodiversity and phytogenetic resources on the one hand, and on the other with investigations into the principle impacts introducing new varieties will have on practical farming.

BIODIVERSITY CONSERVATION MEASURES: EX-SITU, IN-SITU AND ON FARM

Ex-situ collections (gene banks) contain on average some 60% of the existing variations of the main crop plants. In Germany, more than 90% of the genetic material of indigenous crop plants such as spike cereals and sugar beet are already in German ex-situ conservation. Ex-situ measures are essential for the widely structured crop plants and weeds of the convergent development type. The reproduction of the stored material is the main difficulty of ex-situ conservation.

Merging the gene banks of the IPC Gatersleben and the BAZ (earlier FAL) would create a central German gene bank. Its capacity for long term storage and regeneration should then be developed and expanded. Furthermore, in order to supplement the existing collections, a target-oriented collection strategy should be developed and implemented. Botanical gardens and arboreta should be involved more extensively in ex-situ conservation. Finally, the German collections should be integrated into the global ex-situ network of the FAO.

Germany possesses a great diversity of indigenous genetic resources of ornamental plants and medicinal and aromatic plants, fodder plants and woody plants (including fruit plants). In-situ conservation is the only way of conserving the large majority of wild plants and of maintaining a wide abundance of species while simultaneously guaranteeing continued evolutionary development. Conservation of biodiversity and protection of PGR are not sufficiently mainstreamed in Germany's nature protection activities. Exclusive nature reserves make up hardly 2% of the entire German territory, in contrast to agriculture and forestry which cover some 85%; close cooperation between nature protection and agriculture is therefore extremely important.

In-situ conservation of biodiversity and plant genetic resources should be mainstreamed both in nature protection reserves and also on relevant farm land . In future, biodiversity should be expressly taken into account when determining overall goals, mapping out protected natures reserves and drawing up management and tending plans. Nature reserves which have been isolated to date should be linked via a biotope network system. To conserve the very different varieties and species of pasture plants, for example, differentiated use forms are required that are adapted to local conditions. In order to avoid the degradation of many near-nature ecosystems (and the in-situ involved measures) it is necessary to reduce the inflowing nutrients and pollutants from transport, industry and agriculture.

On-farm conservation is a special type of in-situ conservation for domesticated plants and is characterised by traditional farming and horticultural management practises. On-farm conservation is carried out by cropping and using the species and varieties involved (e.g. old varieties) on farming enterprises. In contrast to conservative conservation (e.g. in gene banks) this is a more dynamic type of conservation which allows evolutionary processes to continue. Whereas in Germany the on-farm diversity of cropping plants is very limited, there is a good outset situation for on-farm conservation of grasses and fodder plants, woody fruit plants and horticultural plants. On-farm conservation is a relatively new concept and long term experience is not yet on hand.

More in-depth conceptual processing has to be carried out on on-farm conservation and suitable promotion instruments need to be developed. Cooperation between government agencies and academia with NGOs and interested parties are particularly important for on-farm conservation. On-farm conservation provides an opportunity to protect , tend and develop valuable cultural landscapes (cultural ecosystems). A major condition for successful on-farm measures to this end is to network interested parties from agriculture, nature protection, economics and tourism on the basis of a strategy of targeted cropping of phytogenetic resources in the pertinent areas.

Ex-situ, on-farm and in-situ conservation each have specific advantages and disadvantages. By concentrating on just one of these approaches it is not possible to satisfy the needs of conservation in general, nor achieve sustainable use of phytogenetic resources. Greater weighting still has to be given to on-farm and in-situ conservation of PGR. To conserve biodiversity as such, in-situ conservation is of major importance. Coordination and cooperation between the different conservation approaches are seldom practised in Germany and the different conservation potentials are not systematically combined.

As Germany does not yet have a coordinated procedure to conserve PGR which incorporates all forms of conservation, a combined conservation strategy should be developed and applied. The overall strategy should follow the principle of conservation through use rather than conservation for use. The recommended council of experts on phytogenetic resources should be appointed immediately by the Federal Ministry of Food, Agriculture and Forestry.

IMPLEMENTING INTERNATIONAL OBLIGATIONS

The Federal Republic of Germany has undertaken important international obligations in the Convention on Biodiversity (CBD, Rio 1992) and the global action plan for the conservation and sustainable use of phytogenetic resources (GPA Leipzig 1996). Conserving biodiversity, particularly PGR, in the centres of genetic diversity is very important for Germany and for German agriculture. Moreover, it is necessary to harmonise the international agreements on biodiversity and on PGR.

The Federal Republic of Germany should advocate a harmonisation between the conventions and agreements on the protection of biodiversity and PGR. Efforts should also be stepped up to regulate access and advantage offsetting in the use of genetic resources (taking into account international trade and patent agreements), the development of technology transfer and research cooperation (»clearinghouse mechanisms”), and to obtain rapid agreement on the »Biosafety Protocol« and improved international financing.

The theme of biodiversity is very transsectoral in character. At Federal level the German Ministry for Environment, Nature Protection and Reactor Safety is responsible for the Convention on Biodiversity, the German Ministry of Food, Agriculture and Forestry for phytogenetic resources. The task of conserving biodiversity and phytogenetic resources also addresses different sector policies and departments at the levels of EU, the Federation and individual States, although many of these institutions display a low understanding and acceptance of this new task. The German government’s paper on biodiversity, coordinated by the BMU and presented as part of the obligations under the Convention on Biodiversity, lays out a strategic framework concept to achieve the action goals concerning biological diversity. In the years to come, the task at hand will be to combine existing activities and approaches being carried out at various levels of society and politics, further develop them and implement them as a national strategy.

Implementing a comprehensive and integrated national strategy on the conservation of biodiversity (including PGR) should enjoy high priority. The significance of the theme and the tasks at hand must be given a clear profile both in public and in various ministries in order to obtain a higher degree of acceptance and willingness to introduce even high-input measures and concepts. As the German Federal Government possesses only outlining competencies in several decisive areas (e.g. nature protection, water management, agriculture and forestry, regional planning) the individual German States (Länder) must increase their commitment to conserve biodiversity. Effective cooperation between the various levels of the state is still in its infancy, and must therefore be improved. In view of the fact that very varied fields of policy, interests and actors are affected, it is continuously necessary to integrate the interested and affected societal groups into efforts to further develop leitbilder, goals and action concepts.

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