Session 1

THE ROLE OF PLANT BREEDING IN MEETING THE MULTIPLE CHALLENGES OF A FAST-CHANGING WORLD

Chairperson: MR. ORLANDO DE PONTI,
President of the International Seed Federation (ISF)

- **The evolution and contribution of plant breeding to global agriculture**
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- **Anticipated demands and challenges to plant breeding and related technologies into the future**
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THE EVOLUTION AND CONTRIBUTION OF PLANT BREEDING TO GLOBAL AGRICULTURE

Mr MARCEL BRUINS*

Summary

Domestication of crops started some 11,000 years ago and since then much progress has been made. In this paper, the history of plant breeding and the seed industry is discussed, together with the most important developments in this sector. Plant breeding has made an enormous contribution to global agriculture (yield, resistance to biotic stress, tolerance to abiotic stress, harvest security, improvement of quality traits including nutritional value, etc.). Yield in many crops has increased from 1 to 3 per cent per year. A large proportion (50 to 90 per cent) is due to improved varieties, rather than to other input factors, and in certain crops this percentage is increasing. The efforts of plant breeders have led to varieties with increased resistance to biotic stress, saving many millions of dollars in crop protection products per year, as well as to varieties with increased tolerance to abiotic stress, such as drought, salinity, flooding or herbicides.

Plant breeding is an activity that requires a considerable amount of skill and financial investment to support the lengthy and risky processes of research and product development such as intellectual property (IP), which is crucial for a sustainable contribution to plant breeding and seed supply and mechanisms need to be in place to ensure a return on investment. Plant breeding and related disciplines and technologies have the ability to significantly contribute to solving several possible future problems such as food insecurity and hunger, high input costs, etc. They can also offer increasing nutritional values and other traits useful for mankind. This is how plant breeding is mitigating the effects of population growth, climate change and other social and physical challenges.

Introduction

Broadly speaking, plant breeding could be considered to be changing the genetic make-up of plants for the benefit of humankind. More specifically, it is developing new varieties through the creation of new genetic diversity, by reassembling existing genetic diversity all with the aid of special techniques and technologies.

The precursor to plant breeding as we know it today began 9,000 to 11,000 years ago when man domesticated wild plants. By a process of trial and error, plants with desirable traits were selected – the process often referred to as domestication – rendering them more suitable for agriculture. Within a relatively short time frame of several thousand years, all the major cereal grains, legumes, and root crops have been domesticated. These are the food crops that mankind has depended on most for its calorie and protein intake.

Source, Crispeels, 2008

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Since then, there have been many noteworthy break-throughs in plant breeding and promising research activities to raise yields in marginal production environments are ongoing. Today, plant breeding uses techniques from simple selection to complex molecular methods to integrate desirable traits into existing varieties to meet human needs. Whether carried out by the public or private sectors, plant breeding is an activity that requires skill and financial investment to support the lengthy and risky process of research and product development.

Plant breeders work with all kinds of crops, such as agricultural (or field) crops, horticultural crops (including ornamentals), forage and turf crops and forest crops. Crops producing medicines or providing environmental remedies are also within their sphere of action. In order to find and create enough genetic variation, they are involved in the collection of germplasm around the world. They preserve, evaluate and distribute the germplasm to those interested in working with the crop. The products of plant breeding can be found everywhere in the form of new varieties of useful crops for growers, farmers, and gardeners. Plant breeders develop new cultivars which give higher yield, earlier maturity, better adaptation, improved quality, and higher resistance to disease, insects, and environmental stress, just to name a few of the characteristics that benefit mankind.

It is mainly the plant breeders, along with other agricultural researchers and extension services, who have provided the world's population with plentiful food, improved health and nutrition and beautiful landscapes. Agriculture can be considered to be the foundation of civilization, and in a similar way, plant breeding can be considered to be the foundation of agriculture.

The International Seed Federation (ISF) represents the seed industry, and therefore this paper will mainly focus on its contribution to global agriculture.

The Seed Industry – a Time Line

Crop improvement until recently, was in the hands of farmers: Darwin and Mendel in the late 19th century laid the cornerstones for modern plant breeding. During the 20th century knowledge of genetics, plant pathology and entomology has grown and plant breeders have made an enormous contribution to increased food production throughout the world.
The commercial seed industry started around the 1740s with the establishment of the earliest known seed company Vilmorin (1743), followed by Tezier (1785), Groot (1813), Comstock (1829), Takii (1835) and several others. The 1850s saw the involvement of the public sector not just in plant breeding but also in the protection of the interests of farmers and consumers: this was also the period that saw the birth of modern plant breeding. New companies such as KWS (1856), Asgrow (1865), Sluis and Groot (1867), Royal Sluis (1868), Weibull (1870), Vander Have (1879), Clause (1891) and many others were established.

The first national seed associations such as the American Seed Trade Association (1883), the Dutch Seed Association (1909), the Polish Seed Association (1919), the Italian Seed Association (1921) and the Canadian Seed Trade Association (1923), to name just a few, were also established.

From 1900 the seed industry entered a period of transition and modernization. The seed sector, both public and private, continued to grow and science and commerce expanded. In the first decades of the 20th century seed traders felt a clear need to establish harmonized trade rules, and this led to the establishment of the International Seed Trade Federation (FIS) in 1924. The desire to protect the fruits of their labor led plant breeders to form the International Association of Plant Breeders (ASSINSEL) in 1938.

Around the same time, several international bodies were created for setting standards and regulations that provided an enabling environment for the seed industry: the International Seed Testing Association (ISTA) in 1924; the International Plant Protection Convention (IPPC) in 1951; the OECD Seed Schemes in 1953 and the International Union for the Protection of New Varieties of Plants (UPOV) in 1961.

In the late 1960s and 1970s in the industrialized countries, a first wave of consolidation in the seed industry was witnessed where chemical corporations and the oil industry began acquiring seed companies. During the 1980s, biotechnology, mainly in the form of DNA marker-assisted selection and genetic engineering, was being used more and more by seed companies. A second wave of consolidation took place in the 1990s with the establishment of the so-called "life science" companies. It should be noted that many small and medium-sized breeding companies were also established.

On the regulatory side, it is worthwhile mentioning the revision of the UPOV Act in 1991 which introduced, inter alia, the concept of Essentially Derived Varieties (EDV); the entry into force of the Convention on Biological Diversity (CBD) in 1993; the signing of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) in 1994 and the establishment of the World Trade Organization (replacing GATT) in 1995. In 2000, agreement was reached on the Cartagena Protocol on Biosafety, which entered into force in 2003. Last but not least, and of particular interest to the seed industry, negotiations on the International Treaty on Plant Genetic Resources for Food and Agriculture (IT-PGRFA) ended in 2001 and it entered into force in 2004.

Annex 1 gives a time line showing significant events for the seed industry.

The Seed Industry Today

This can be characterized by the following developments:

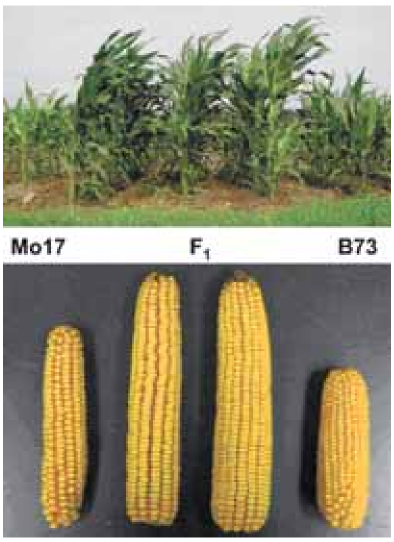
a. An increasing global seed market
b. A growing use of hybrid seeds with several technological components
c. A growing international seed trade
d. An increasing number of regulations
e. An increasing number of multinational companies

a. An Increasing Global Seed Market

The global seed market increased from around 12 billion US dollars in 1975 to around 20 billion US dollars in 1985 and was estimated at 36.5 billion US dollars in 2007. This increase in size is mainly caused by the following factors:

- *Development of Hybrids.* The first hybrids that appeared on the market were corn hybrids in the 1920s. The commercial release of other hybrid varieties started in the mid-1950s with sorghum in 1955, sugar beet in 1962, rice in 1973, rye in 1984, oilseed rape in 1985 and alfalfa in 1998. The first cotton and vegetable hybrids appeared on the market in the 1970s.

  Hybrids offer several advantages to farmers. Due to the effect of heterosis or hybrid vigor, these varieties often outperform the best parent lines, and, in addition, hybrids are highly uniform, another of their characteristics being that they cannot be selfed without changing the genetic characteristics of the variety.



Source: Genome Res. 17: 264-275

- *Increasing Use of Seed Treatment*. The first mention of seed treatment dates back 4,000 years: onion or cypress sap was used on seeds in Egypt, Greece and parts of the Roman Empire around 2000 BC. Salt water treatments have been used since the mid-1600s and the first copper products were introduced in the mid-1700s. Other key milestones were the introduction of arsenic, used from 1740 to 1808, and mercury, used from 1915 to 1982. Up to the 1960s seed treatments consisted only of surface disinfectants and protectants. The first systemic fungicide product was launched in 1968 (ISF, 2007).

  Seed treatment greatly reduces the area of land in contact with a crop protection product, from 10,000 sq. meters for foliar application or 500 sq. meters for furrow application to only 50 sq. meters when the seed is treated. For example, the application rate for an insecticide for corn sown at a rate of 100,000 seeds per hectare reduces from 1,350 grams active ingredient per hectare (ai/ha) for foliar application to 600 grams ai/ha for furrow application and to 50 grams ai/ha for seed treatment (ISF, 2007).

- *Development of Biotech Varieties.* Crops derived with the help of biotechnology were first introduced in 1994 with the "Flavr Savr" tomato variety. They are now grown by more than 13 million farmers in 15 developing and 10 industrialized countries. Biotech crops have shown an increase in yield: Bt cotton yields in China for instance increased by 10 per cent and in India by 31 per cent. Yield increase of Bt maize varieties in South Africa was on average 11 per cent and yield increase of Bt canola in Canada was 10 per cent (James, 2008).

  Biotech crops have also led to a reduction in the use of insecticides; in India and China alone this is estimated to be on average more than 50 per cent. In addition, biotech crops have led to an increased income for farmers. Studies show increased incomes per hectare of 250 US dollars in India, 220 US dollars in China, 117 US dollars in South Africa and 135 US dollars in the Philippines.

  The value of the biotech seed market increased from 115 million US dollars in 1996 to over 7.5 billion US dollars in 2008 (James, 2008).

- *Development of New Markets, especially in Developing Countries*. The estimated value of the world domestic market for seeds has grown from little over 13 billion US dollars in 1979 to well over 36 billion US dollars in 2007, close to a three-fold increase. In several countries the domestic seed market has grown much more vigorously; for example, China had a domestic market of 550 million US dollars in 1979 and it was estimated to have grown to 4 billion US dollars in 2007, a striking seven-fold increase. ISF estimates show other notable rises in Argentina (4.5-fold), Turkey (4.1-fold) and India (four-fold).

b. A Growing Use of Hybrid Seeds with Several Technological Components

As a result of the advantages of hybrid seeds for farmers (see A.), companies have tried to convert crops from open-pollinated or self-pollinated varieties to hybrid varieties. Several important food crops are now mainly sold in the form of hybrid varieties. Notable exceptions are wheat, lettuce, beans and peas which are still mainly self- or open-pollinated. In these crops it has not yet been possible to develop hybrid varieties as a result of technical or economic barriers.

Due to their improved characteristics, these hybrid seeds justify the addition of other components that enhance their potential. The seed price of such hybrid varieties not only includes the value of the genetic material, but also that of several other technological components, such as calibration and other physical improvements: priming, disinfection, chemical treatment (e.g. with fungicides or insecticides) and pelleting or coating. Estimates indicate that in vegetables on average 60 per cent of the price is related to genetics, whereas the remaining 40 per cent is based on other components. When the technology fee that is charged for certain biotech varieties is included, the share of the genetic component in the total seed price could be as low as 30 per cent.

c. A Growing International Seed Trade

The international seed trade grew from a little under 1 billion US dollars in 1970 to around 6.4 billion US dollars in 2007. More and more seed is being moved across borders and the main factors for this increase are:

- Transportation has become cheaper and faster, reaping the benefit of favorable climatic zones such as the East African plains and Idaho (US) for beans or the high plains of Central and South America for flowers.
- The development of hybrid varieties has also led to an increase in more seeds moving across borders. Production of hybrid seeds needs specific conditions both in terms of skilled labor and agro-climatic conditions. For example, the flowering time-difference between male and female maize hybrids requires specific climatic conditions; the production of hybrid vegetables requires skilled labor at a reasonable cost. Thus, for example, hybrid maize in Europe is mainly produced in France, Hungary and Austria, hybrid vegetables in South East Asia and monogerm sugar beet in France, Italy and Oregon (US).
- Finally, the rate of breeding and other commercial processes is more rapid, leading to the development of counter-season production in other hemispheres.

d. An Increasing Number of Regulations

To achieve any significant progress in agriculture, the availability of high-quality seed of the improved varieties at a reasonable price is a prerequisite. Significant changes in plant breeding, seed multiplication and trade have been brought about by modern agricultural practices combined with the establishment of the WTO and TRIPS, including Plant Breeders' Rights (PBR). As more and more seed is being moved around the globe, regulations have been put in place to guarantee a sustainable supply of high quality seed. As a result, the industry today is faced with more and more regulations, particularly in intellectual property and variety registration, seed certification and phytosanitary matters. Recent developments show a rise in regulations in relatively new sectors such as organic seeds, biotech varieties and chemically treated seeds.

e. An Increasing Number of Multinational Companies

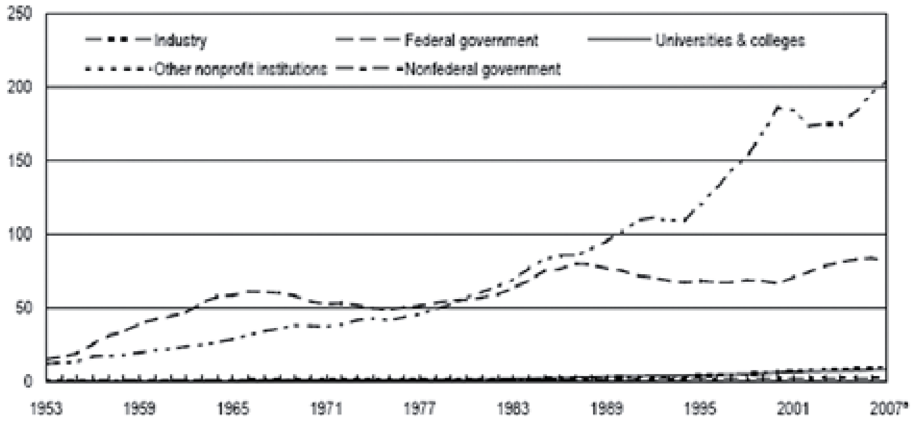
Over the last two decades there has been a significant concentration in the commercial seed industry mainly in industrialized countries. According to calculations made by the ISF, in 1985 the 10 largest seed companies accounted for approximately 12 per cent of the market, increasing to almost 40 per cent in 2007. The major factors responsible for this situation are:

- The increasingly sophisticated technologies used in plant breeding which require substantial investment in research, development and seed production and where economies of scale through mergers have been necessary.
- A need to speed production has caused a loss of specificity of various steps in breeding and a resulting vertical integration of the seed industry. Companies specializing in either breeding or production have decided to integrate their businesses.
- A certain synergy through which R&D is shared across multiple product lines.
- Barriers to entry created by different regulations.

It must be noted that the seed industry is still relatively fragmented when compared with other providers such as the crop protection industry where the top 10 companies represent more than 85 per cent of the market (ETC, 2005).

The possibilities offered by IP protection of plant varieties and biotechnological inventions have encouraged companies to increase their spending on R&D: the plant-breeding industry spends on average 10 to 15 per cent of its annual turnover on this. In contrast, public spending on research and teaching has grown at a much slower rate since the oil crisis of 1973 led to an economic crisis in the western world, making it more difficult for states to maintain their levels of funding. These two factors combined have contributed to a growing divide in the percentage of R&D spending between the private and public sectors (Fig. 1).

Fig. 1 R&D Expenditure by Source of Funding in the US: 1953-2007



* Figures for 2007 are estimates.

Source: National Science Foundation, Division of Science Resources Statistics, National Patterns of R&D Resources (annual series).

In this respect it should be noted that ISF members are unanimously in favor of strong and effective IP protection to ensure an acceptable return on research investment, which is a prerequisite to encouraging further research efforts and essential to meet the challenges mankind has to face in the coming years, such as feeding an increasing population while preserving the planet. All of these endeavors require substantial, long-term and high-risk investment.

In the countries where plant varieties can be protected, a UPOV or UPOV-type system is available. There are a few countries where protection through utility patents is also possible and the ISF considers both systems to be legitimate. If a country envisages the adoption of a sui generis system to protect plant varieties, the ISF recommends that this has at least to conform to the requirements of the 1991 Act of the UPOV Convention (ISF, 2009).

ISF members also consider that breeders' rights (and patents for plant varieties where allowed by law) and patent protection for biotechnological inventions offer good protection. It is thus necessary to define fair coexistence of the two rights. The introduction of the concepts of essential derivation and dependency in the 1991 Act of the UPOV Convention is a welcome initiative to this end and is in the interests of everyone.

However, further clarification is needed as regards the use of biotech varieties containing patented elements and protected by breeders' rights for further breeding. ISF members are strongly attached to the breeders' exception provided for in the UPOV Convention and have expressed their concern that the extension of the protection of a gene sequence to the relevant plant variety itself could extinguish this exception.

ISF members therefore consider that a commercially available variety protected only by breeders' rights and containing patented elements should remain freely available for further breeding.

If a new plant variety, not an essentially derived variety resulting from further breeding, is outside the scope of the patent's claims, it may be freely exploitable by its developer. On the contrary, if the new developed variety is an EDV or if it is within the scope of the patent's claims, consent from the owner of the initial variety or the patent must be obtained (ISF, 2009).

Contribution of Plant Breeding

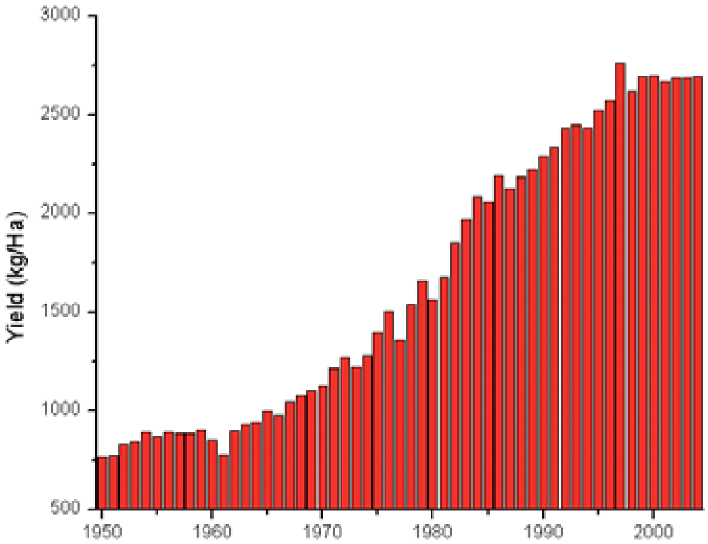
Numerous contributions have been made by plant breeding and over the years plant breeders have focused on increasing the yield of varieties, on resistance to biotic stress and tolerance to abiotic stress. Other factors that have been altered for the benefit of mankind are: earliness, taste, size, nutritional and crop quality, firmness, shelf-life, plant type, labor costs and harvestability.

Yield

Arguably the most important of all characteristics is yield. Studies in different crops over many years show that yield has increased from 1 to 3 per cent per year. At first sight 1 per cent may not seem much, but when added up over many years it is a significant contribution. Over the past 30 years, in irrigated wheat, a yield increase of about 1 per cent per year has been achieved, which can be compared to an increase of around 100 kg per hectare. per year (Pingali and Rajaram, 1999).

This yield increase is not restricted to industrialized countries: FAO data for all developing countries indicate that wheat yields rose by 208 per cent from 1960 to 2000; rice yields rose 109 per cent; maize yields rose 157 per cent; potato yields rose 78 per cent; and cassava yields rose 36 per cent (FAOSTAT).

Fig. 2 Wheat yields in developing countries, 1950-2004



Source: FAO

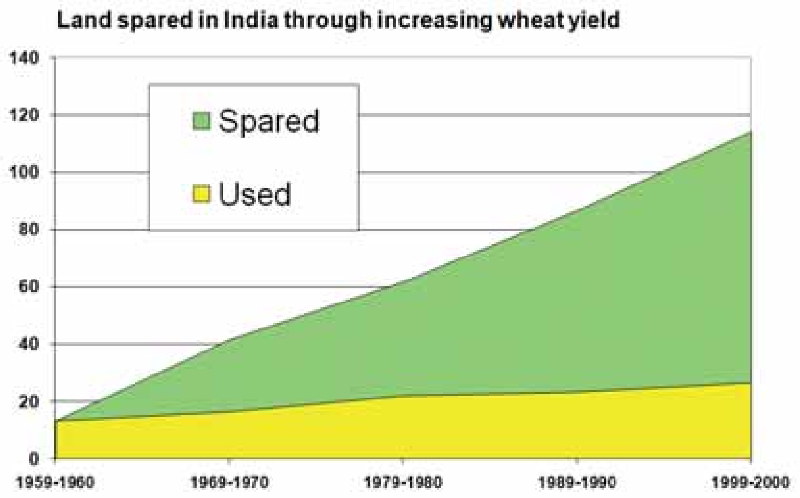
Winter wheat yields in the UK have more than trebled over the past 60 years from around 2.5 tonnes/hectare in the mid-1940s to 8 tonnes/hectare today. To determine the effect of genetic improvements on the total yield increase, the National Institute of Agricultural Botany (NIAB) in the UK carried out a study in 2008 in which 300 varieties of wheat, barley and oats were analyzed in 3,600 trials, leading to 53.000 data points. Previous studies had already indicated that in the period 1947 to 1986 about half of the increase in yield could be attributed to plant breeding: the rest of the increase was due to improvements in fertilizer, crop protection products and machinery. The 2008 analysis revealed that in the period between 1982 and 2007 in which yields went up from 5 to 6 tonnes/hectare to 8 tonnes/hectare, over 90 per cent of all yield increase could be attributed to the introduction of new varieties. This clearly shows the contribution of the genetic component to yield increase.

Land Spared

Because yield has increased steadily over the years, plant breeders have contributed to a saving in the use of land which would otherwise have been needed to achieve the same level of production.

For example: India's cereal production increased from 87 million tonnes in 1961 to 200 million tonnes in 1992 on an arable land base that has remained almost constant, and in that way has helped to limit the extension in land use . Between 1950 and 2001, the world's population grew from 2.5 billion to 5.5 billion, although the land devoted to agriculture remained stable at around 1.4 billion hectares. It has been calculated that 26 million square kilometers of land were saved and this will certainly increase in the future (CLI, 2001). This means that deforestation has decreased and biodiversity has been maintained.

Fig. 3 Amount of Land saved in India in Millions of Hectares in the Period 1959-2000



Biotic Stress Resistance

According to FAO data, the current annual loss worldwide due to pathogens is estimated at 85 billion US dollars and to insects at 46 billion US dollars. Therefore it is not surprising that a considerable amount of effort goes into breeding for biotic stress resistance. This involves, inter alia, resistance against fungi, bacteria, nematodes, viruses, water moulds and insects. Over the years breeders have released thousands of varieties with as much or higher resistance. In that way they have given farmers the necessary harvest security to ensure that they have a crop to harvest at the end of the growing season.

With this breeding for biotic stress resistance, there has been significantly less need to use crop protection products, resulting in a significant decrease in the environmental footprint made by agriculture. It has been calculated that in the UK alone, disease resistance saves 100 million pounds sterling per year on crop protection products (BSPB, 2009).

However, it should also be said that there is still a lot of work to do. For example fully resistant varieties against three fungal diseases affecting cereals and grasses, Fusarium head blight (FHB), ergot and stem rust, are still needed. It is estimated that FHB causes an annual loss of 1 billion US dollars in wheat yield and grain quality. Reports indicate that in a state such as North Dakota (US) a loss of up to 10 per cent can occur in wheat due to ergot infection, and losses of 5 per cent are common in rye. With the Ug99 strain of stem rust, 100 per cent crop loss has been reported. These are just a few of the examples where the continuous and relentless efforts of plant breeders are desperately needed.

Abiotic Stress Tolerance

Ninety million people per year are affected by drought, 106 million people per year are affected by flooding and around 900 million hectares of soil are affected by salinity. In addition, according to FAO data, the current annual loss worldwide to weeds is a staggering 95 billion US dollars. Of this, around 70 billion US dollars is lost in developing countries, which is equivalent to a loss of 380 million tonnes of wheat.

Plant breeders have also worked on tolerance to abiotic stress factors such as herbicide tolerance, drought, flooding and salinity. In the case of poor soils, breeders have attempted to select varieties which were better capable of taking up the necessary nutrients. When considering the possible effects of climate change, certain areas are expected to see a decrease in the level of rainfall, whereas other areas could expect the reverse. Plant breeders will therefore continue to research and create new genetic variations to develop the necessary germplasm to cope with these challenges.

The figures given above underline the magnitude of the task ahead and the need to have a good plant breeding infrastructure and seed industry in place.

Nutritional Quality

The concept of nutritional quality is fairly new but is becoming more and more important. As an example, around 124 million people annually in 118 countries are affected by vitamin A deficiency leading to 1-2 million deaths and causing blindness in around 500,000 children each year. Rice is a staple food crop for about half of the world's population and it was no surprise that this crop was chosen to try and introduce carotenoid levels in the rice grain. Rice varieties with high levels of beta carotene, the precursor of Vitamin A were developed and were named "golden rice". It is interesting to note that around 70 intellectual property rights (IPRs) from 32 companies were relinquished to make this commercially possible and market release is planned for 2011 (www.goldenrice.org). Other interesting developments are, for example, varieties of broccoli with higher levels of the cancer-fighting compound glucosinolate, or tomatoes with higher levels of the anti-oxidant lycopene.

Crop Quality

Plant breeders have adapted crops in many different ways, and here are a few examples. Brussels sprout hybrids have been developed with uniform ripening and size to make them suitable for machine harvesting; monogerm sugar beet varieties have been developed, thus reducing the need for laborious thinning and enabling fully mechanized cultivation; malting quality in barley has been improved, producing 2,000 liters of beer per tonne in 1950 rising to 8,000 liters in 2008. Taste in vegetables has been greatly improved, as well as the number of health components.

The Green Revolution

This can be characterized by the combined use of high-yielding varieties, fertilizer, irrigation, machinery and crop protection products and began in 1945. In the years before the onset of the green revolution, Mexico imported half of its wheat, whereas in the mid-1950s, the country had become self-sufficient and a decade later was able to export half a million tonnes (Dewar, 2007). Agricultural research, extension programs and infrastructural development were also improved (Parks, 2006).

In 1961, India was on the brink of famine (National Geographic Magazine, 2001), but as a result of the green revolution, India's wheat production increased from 10 million tonnes to 73 million tonnes between the 1960s and 2006 (BBC, 2006; CGIAR, 2007). This was accompanied by an increase in land use of only 9 million hectares (from 14 to 23 million hectares). Without the benefits of the green revolution, utilizing the best results of plant breeding, crop protection, irrigation, mechanization and education of farmers, many millions of hectares of habitat would have been plowed under (CLI, 2001).

A few examples of the contributions of plant breeding can be found below. They highlight the benefits of combined public and private efforts toward producing varieties with more desirable traits which will benefit mankind.

New Rice for Africa (NERICA)

Rice is a major food and energy source in large parts of West Africa and currently about 1 billion US dollars of rice is imported annually.

For the past 3,500 years, African rice (Oryza glaberrima) has been cultivated and is well adapted to the African environment. It is resistant to the rice gall midge, rice yellow mottle virus, blast disease and to drought. In addition it has a profuse vegetative growth which keeps weeds at bay. However, this rice type easily lodges and produces relatively low yields. An additional problem is that the grains may shatter and this also decreases the yield. As a result the cultivation of African rice was abandoned in favor of high-yielding Asian varieties (O. sativa) which were introduced into Africa some 500 years ago. However, these Asian varieties require abundant water and are poorly adapted to African conditions as they are too short to compete with weeds and are also susceptible to several of the African pests and diseases.

In an attempt to overcome these problems, the African Rice Center (WARDA) with the help of plant breeders developed new rice varieties by crossing these two types. Normally they do not interbreed so embryo rescue techniques had to be used. Upland and lowland varieties were developed showing heterosis and outperforming the best parents.

One of the main features of these Nerica lines is that yield could be increased from about 1 tonne/hectare to about 2.5 tonnes/hectare. With the use of fertilizer, yields of 5 tonnes/hectare were reached. The new lines have 2 per cent higher protein content, are resistant to pests and are taller than most other varieties, making them easier to harvest. Some of the newly developed lines are giving good results with relatively low amounts of water and could therefore be adapted to drought conditions (Nerica, 2009).

Tropical Sugar Beet

Water shortage is a major problem in many parts of the world and it is a well-established fact that sugar beet can be grown in relatively dry areas as the crop requires substantially less water than sugar cane. In an attempt to provide crops that use less water, plant breeders have developed tropical sugar beet varieties that yield the same quantity of sugar per land unit as sugar cane but use only one third to one half the amount of water. In this way, up to 10,000 cubic meters of water per hectare could be saved.

An additional benefit is that these new varieties grow faster, allowing farmers to grow a second crop in the same period it would take sugar cane to mature. Therefore, in one hectare, about 10 tonnes of white sugar could be produced in five to six months instead of a year. This type of tropical sugar beet could also be cultivated on saline or alkaline soils which would otherwise be unsuitable for cane or other crops. And, last but not least, studies show that the plant removes the same amount of atmospheric carbon in half the time as does sugar cane (Syngenta, 2007).

Water Efficient Maize for Africa (WEMA)

Maize is a major staple crop but in certain areas suffers from drought which makes farming risky for millions of small-scale farmers who rely on rainfall to irrigate their crops.

Plant breeders have recognized drought tolerance to be one of the most important targets of crop improvement programs. The WEMA project is a public-private partnership in which plant breeders are developing drought-tolerant maize using conventional breeding, marker-assisted breeding, and biotechnology. Combined with other efforts such as the identification of ways to mitigate the risk of drought, to stabilize yields and to encourage small-scale farmers to adopt best management practices, it will be fundamental for realizing food security and improving the livelihoods of these farmers (AATF, 2009).

Africa Biofortified Sorghum (ABS)

Sorghum as a crop has a high fiber content and a poor rate of digestibility of nutrients and these are major contributors to low consumer acceptance. Combined with unpredictable rainfall, declining soil fertility, inefficient production systems and biotic and abiotic stress they have caused a decline in its production. Through the use of plant breeding, including related technologies, the ABS project endeavors to develop a more nutritious and easily digestible sorghum containing increased levels of vitamin A, iron, zinc and several essential amino acids, such as lysine. The success of the project could improve the health of 300 million people (Biosorghum, 2009).

There are thousands of other good examples of the contribution that plant breeding has made to global agriculture which unfortunately cannot all be covered in this paper.

Responding to the Challenges

Taking account of the foregoing, it is safe to say that plant breeding has increased food security, in many ways and has contributed to the alleviation of hunger and poverty and resulted in higher nutritional value. Resistant varieties have led to a reduction in the use of crop protection products and in the use of fossil fuels. With certain varieties there is no or less need for plowing, thus decreasing CO2 emissions and improving soil conservation and water content. Increased yields have reduced the need for more land cultivation and have decreased deforestation, contributing to the conservation of biodiversity and better carbon sequestration.

Conclusion

In the words of Nobel Peace Prize winner Norman Borlaug, plant breeders have made an enormous contribution to food production, global agriculture and the general well-being of mankind and have a tremendous potential to continue to do so (Borlaug, 1983). However, this cannot be done without the necessary regulatory and other changes towards providing an environment in which all stakeholders can work together in a mutually supportive way towards a constant supply of high quality seeds.

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ANNEX 1 TIME LINE OF SIGNIFICANT EVENTS FOR THE SEED INDUSTRY

1859 *On the Origin of Species - Darwin*
1866 *Experiments on Plant Hybridization – Mendel*
1869 Discovery of DNA from nuclei – Miescher
1883 *Paris Convention for the Protection of Industrial Property* – World Intellectual Property Organization (WIPO)
1900 *The Rediscovery of Mendel Laws* – de Vries and Correns
1902 Culture of isolated plant cells – Haberlandt
1904 First embryo culture - Hanning
1908 The discovery of heterosis (hybrid vigor) – Shull
1919 *Identification of the Base, Sugar and Phosphate Nucleotide Units of DNA* - Levene
1920s Quantitative genetics and breeding developed
1921 First commercial double cross in corn hybrid released
1922 First haploid reported – Blakeslee et al.
1930s First experiments with seed coating
1933 CMS developed in maize
1939 First continuously growing callus cultures – Gautheret, White and Nobecourt
1943 Confirmation that DNA carries genetic information – Avery, McCleod and McCarthy
1948 Discovery of transposition - McClintock
1950s Development of tissue culture media – Skoog et al.
1953 Induction of haploid callus from mature pollen grains – Tulecke
1953 Description double-helix structure of DNA – Watson and Crick
1955 First field of hybrid sorghum planted
1958 Development of somatic embryos – Reinert and Steward
1959 First plant regenerated from mature plant cell – Braun
1960 Production of large quantities of protoplasts – Cocking
1961 First RNA base described – Nirenberg and Matthaei
1965 Completion of genetic code deciphering
1964 Embryo formed in anther culture, haploid plants regenerated – Guha and Maheshwari
1960s Commercial development of seed coating
1968 First systemic fungicide
1971 Commercial seed priming
1972 First somatic hybrid after protoplast fusion – Carlson et al.
1973 Invention of DNA cloning and genetic engineering
1980 Description of the first polymorphic marker
1980 US Supreme Court Chakrabarty decision allowing patenting of living organisms
1977 *Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure* – WIPO
1983 RFLP in plants => molecular marker-assisted selection
1983 Stable transformation of plants by genetic engineering
1985 First transfer of a gene coding for an agronomic trait (herbicide tolerance in tobacco)
1988 First transgenic plant with a "quality" trait (delayed ripening in tomatoes)
1990s New classes of fungicides, insecticides and nematicides
1994 "Flavr Savr" tomato introduced
1995 Bt-corn introduced, 1.5 million hectares of biotech crops
1996 RR soybeans introduced
2008 125 million hectares planted with biotech crops

Discussion

ORLANDO DE PONTI (ISF): Marcel, it was both in the presentation of Bernard Le Buanec and yourself, and that was new to me, that there has been a shift in the contribution of plant breeding in terms of percentage. For many years I have always mentioned the 50/50 split: there was a 2 per cent yield increase per year, 1 per cent due to genetic improvement, 1 per cent due to, as I say, agronomy. And it was for me quite interesting to note that it has been published that today this is 90 per cent. It was mentioned of course that this is due to the investment in plant breeding, on the other hand, my question is also to you Marcel, whether it also gives a sign, and although this is not the topic of this conference, that maybe the world is not investing enough or taking enough care of the potential of agronomy?

MARCEL BRUINS (ISF): We've seen that investments have been low in all agricultural fields, in all agricultural R&D fields, so also in agricultural technology, in plant breeding, in plant pathology, seed testing, just to name a few. I think agriculture has been taken for granted for too long. It was just there and we have even seen the disappearance of Ministries of Agriculture here and there in certain countries, moving to Ministries of Consumer Affairs and the like. So yes, I do agree that there has been negligence, a lack of necessary investment in that field. I also speculate that maybe at a certain point you reach a level of the maximum attainable yield because of fertilizers. You can only put so many fertilizers on a field. After that it will become harmful to the crops. So I think that might also contribute to the plateau that you see with those other input factors, and that it is now mainly up to genetic improvement to provide us with the necessary yield increase.

BERNARD LE BUANEC (ORGANIZING COMMITTEE): Just a comment on your question as well Orlando. In fact we see at the moment in the world a shift and a very strong demand for decreasing the inputs. And that is for me probably the most important point. But for agricultural practices we are used to high input agriculture and we are moving to low input agriculture. And you have a completely new paradigm to work on and to see how to be efficient with that low input. So we have that and of course plant breeding will be something extremely important. We have to think of a new way of growing crops with low inputs and that is a completely new approach.

ORLANDO DE PONTI (ISF): Thank you, I agree with you. But that of course is agronomy and research because to decrease the input you have to know what you do or what the farmer does. And we all know that we are moving now into what we call precision agriculture but, as you will learn today, also into a time of precision breeding. And the two go together in order to optimize or to maximize yields.

JAI SINGH (ASIA PACIFIC SEED ASSOCIATION): My question to Marcel is: if you see this development so far, it needs a lot of contributions from traditional plant breeding and from now on the private companies are shifting towards biotechnology. How do you anticipate in the future the role of traditional plant breeding? Because if you look at the system now you don't find traditional plant breeders. So how do you see in the future whether this is going to be decreasing or of no relevance or is it all biotechnology from now on?

MARCEL BRUINS (ISF): There needs to be very good cooperation between the public and the private sector, that is becoming clearer every day. I think in certain crops for example, wheat or rice in which private companies until now may not have been so active, it will remain necessary to continue the breeding activities. There you will see the need to keep up a very good public breeding infrastructure to make sure that the necessary germplasm is introduced into partly or fully commercial varieties. The role for public breeding seems to be shifting towards pre-breeding, making sure that through fundamental research the necessary genes are introduced into the material and then half the material is released to private seed companies, where these exist. Of course where these companies are not available, the public seed sector will continue to provide those commercial varieties. And I would not say that biotechnology is just used by the private sector: I have seen a lot of examples where biotechnology has been fully introduced into the public seed sector as well. I don't see that clear split but the need for good cooperation between public and private is clearer than ever.

ORLANDO DE PONTI (ISF): I would like to follow up a little bit on this and get some clarification from you Mr. Singh, because you used the words "participatory plant breeding", and of course we all know it, but I am used to the fact that you get quite a variety of explanations for what it really is. Could you give your explanation of what you feel participatory plant breeding means for your part of the world, as President of APSA, and whether you see potential for it in terms of the challenges ahead?

JAI SINGH (ASIA PACIFIC SEED ASSOCIATION): My concern was actually coming from the South Asian part of the world but if you look 30-40 years back we used to find that very good plant breeders came from the universities or research institutes. But these days if you talk to any university, if you go to any research institute, and especially if you want to recruit typical traditional plant breeders, you don't find them so my concern was that everybody is shifting towards biotech matters; for example marker-assisted breeding and all other biotechnologies, but you don't find the real breeders who can emasculate and pollinate and similar activities. You don't find those breeders in the system currently.

BERT VISSER (CENTER FOR GENETIC RESOURCES, THE NETHERLANDS): I have a similar concern and this relates to some of the opening remarks where, Mr. Chairman, you said that plant breeding is becoming an increasingly interdisciplinary sector. It is based on your report on golden rice and the contribution that this has made to the health of our global population. I'm not going to challenge that. I think that is very important. But it also shows in which direction plant breeding is going. My point is that it is now focusing on rice, as one of our main staples and it is helping us to overcome the problem of vitamin A deficiency, but there is so much more in terms of micronutrients, vitamins that we need from our food. And we cannot go on and correct that by improving rice. We also need to diversify the diet of the global population. My question then is how can it promote investment in all those other crops that can provide a diversified diet on which many people will continue to be dependent and this concerns so many neglected and unutilized crops as we have come to know them? So how can we promote investments in those crops?

MARCEL BRUINS (ISF): I think there is merit in starting with a major staple. You will immediately reach an enormous population with that staple. I should also add that other crops have already been released with improved nutritional quality. I've read several reports where other crops with increased nutritional value have become available. So when those varieties of those major staples have been improved where necessary and are put on the market and traded everywhere, I'm sure we'll see efforts in other, minor crops. But for me it is logical to start with a major staple to reach as many people at the same time as possible.

ANTICIPATED DEMANDS AND CHALLENGES TO PLANT BREEDING AND RELATED TECHNOLOGIES INTO THE FUTURE

Mr. MARCEL B. KANUNGWE*

Introduction

The selection of plants to give higher yields with improved quality has formed the basis of plant breeding since man first domesticated wild plants. The evolving constraints, caused by climate change and the need to feed a growing world population, has brought about the current food crisis and requires a significant improvement in crop yields in a relatively short time. There is a rising demand for the seed industry and governments to utilize both current and new breeding technologies more efficiently, but this can only be done through establishing goals (Fig. 1 shows Pannar Seed (Pty) Ltd's corporate breeding goals for hybrid maize) in collaboration with farmers.

Plant breeding on its own will not deliver the required food increase without the use of supportive technologies such as transgenic technology, irrigation, electricity, plant and equipment, etc.

Robynne M. Anderson summed it up well in her article "Putting Farming First" (Seed World, 2009 Edition) by saying that "the approach starts by focusing on farmers, the tools and information they need to steward land, grow crops, bring in their harvest and then get it to market. New investments, incentives and innovations are needed to achieve greater sustainability while delivering increased agricultural production".

This opinion together with the seed industry's corporate breeding goals already mentioned sum up the demands, challenges and opportunities of the past, present and future for global agriculture in general and plant breeding in particular.

Fig. 1 Corporate Breedings Goals

ULTRA EARLY/DROUGHT TOLERANT	
EARLY/DROUGHT TOLERANT	PAN 4M-19
EARLY	PAN 6363
MEDIUM	PAN 67,53
LATE HIPO	PAN 61,6777
VERY LATE	PAN 69,7M-89
ULTRA LATE	PAN 691,683

Anticipated Demands

Changing Farmers' Needs

Farmers are in general becoming more specific in their demands for farm inputs. This is due to the hostile environments they face and the higher operational efficiency they need to attain economic viability.

* Director, Pannar Seed Ltd, Zambia

The seed industry has the task of meeting farmers' specific needs both in terms of product and information. Further, it has to provide adequate information on product performance consistent with the environment (Figs 2 and 3 give product performance under low- and high-potential growing conditions).

In order to address these needs, the seed industry has set the following goals:

- Developing varieties of all maturities from ultra early to ultra late.
- Providing varieties that will perform well in major growing areas, across seasons and circumstances (erratic rainfall (heavy/late rains) and high altitude).
- Developing varieties with sound agronomic traits (cob, leaf and stem disease resistance, standability and hard grain for storability for small-scale farmers).

Particular attention must be paid to the needs of the latter category of small scale farmers (provision of very early flowering and maturing varieties).

Fig. 2 High And Medium Potential Trials - ART Trials 2007/08 8-11T/Ha

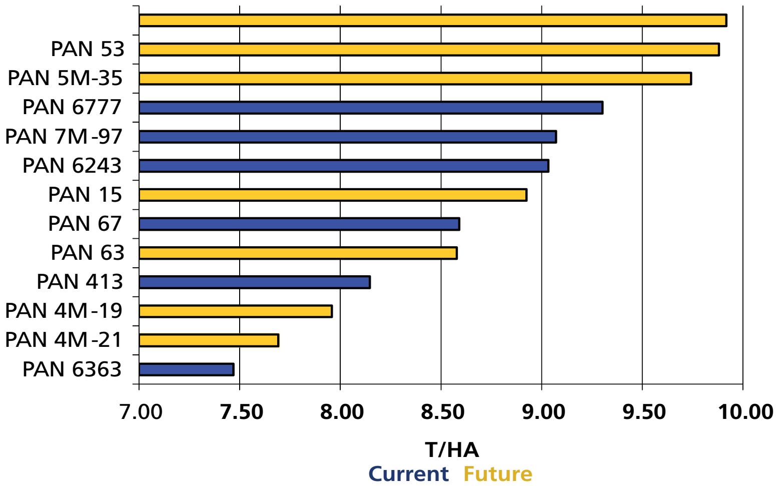
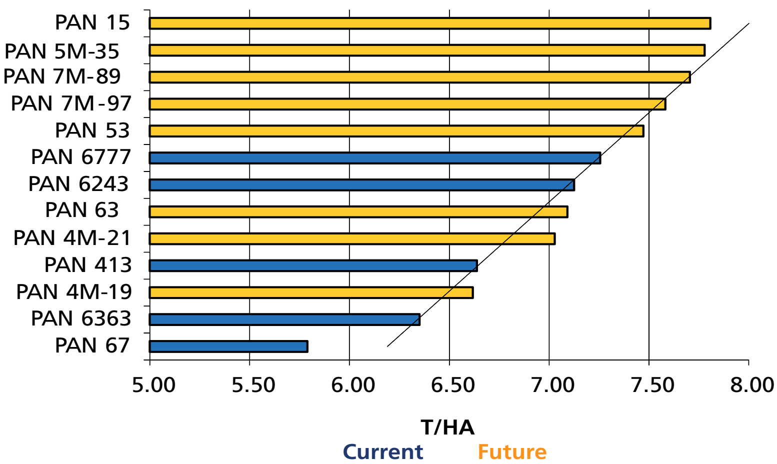


Fig. 3 Medium and Low Potential Trials - ART Trials 2007/08 5-8T/Ha



Development of Infrastructure

Development of infrastructure such as roads, bridges, electricity etc. is a top priority in developing countries as these form the basis for the exploitation of new and advanced technology. One example is the expansion of irrigated land in Indonesia to empower small-scale farmers to produce rice which will maximize output from advanced breeding material.

In sub-Saharan Africa, with vast stretches of land and abundant water resources (rivers and lakes), one would expect the region to have enhanced this potential in order to take advantage of improved varieties.

The common market for Eastern and Southern Africa (COMESA) and the Southern African Development Community (SADC) continue to commit less than 10 per cent of their annual budgets, contrary to an earlier resolution. Unless adequate finance is committed to agriculture, there is little possibility that the present and future agronomic potential of high-yielding varieties will be realized.

Challenges

Population Growth

The present world population stands at 6.8 billion and will reach 9.2 billion by 2050. It is becoming evident that, given a more and more hostile environment to contend with, extra effort will be required to improve plant breeding and supporting technologies will need to be implemented to produce more food. Figs 4a, 4b and 4c show development and deployment of high-yielding maize hybrids at all levels of maturity, from which it will be observed that new products are providing a significant increase in mean relative yield (MRY) over current products.

Fig. 4a Medium hybrids > 8t/Ha

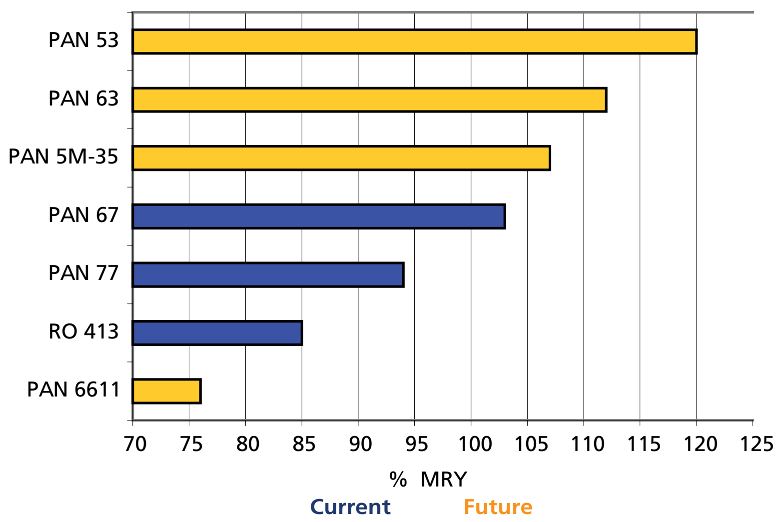


Fig. 4b

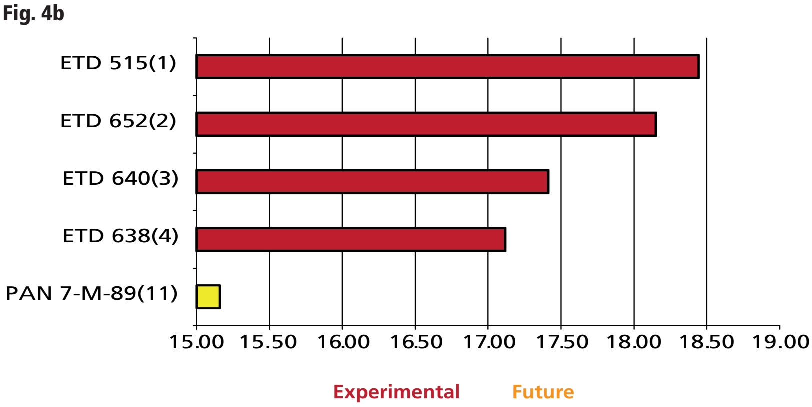
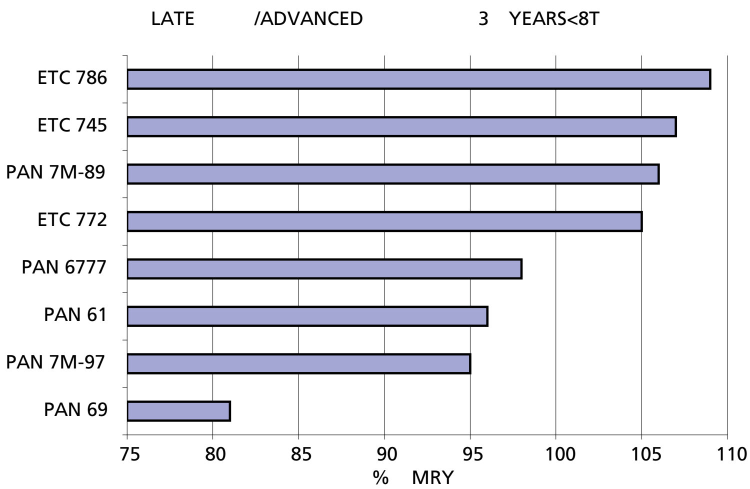


Fig. 4c Late / Advanced 3 years < 8T



Access to Suitable Germplasm

Taking account of the different environments, we consider that new products will lead to better agronomic performance in addition to offering increased overall yield.

Stress factors such as drought, high temperature and high precipitation are taken into consideration in breeding programs. Germplasm stability is critical and is shown in Figs 5 and 6; maize does better with medium rainfall. Achieving good results with the same products in conditions of high or erratic rainfall will mean expanding production areas.

High altitude areas are being brought into focus and suitable germplasm is being screened and put into production.

Fig. 5 High Rainfall - Commercial Hybrids

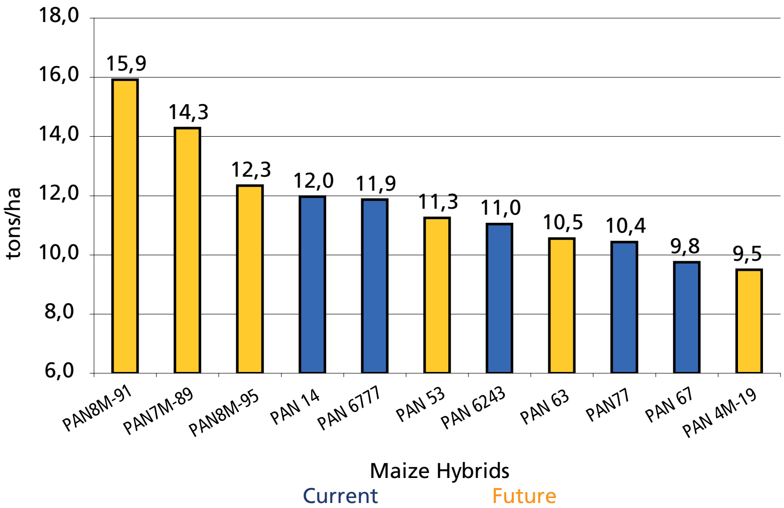
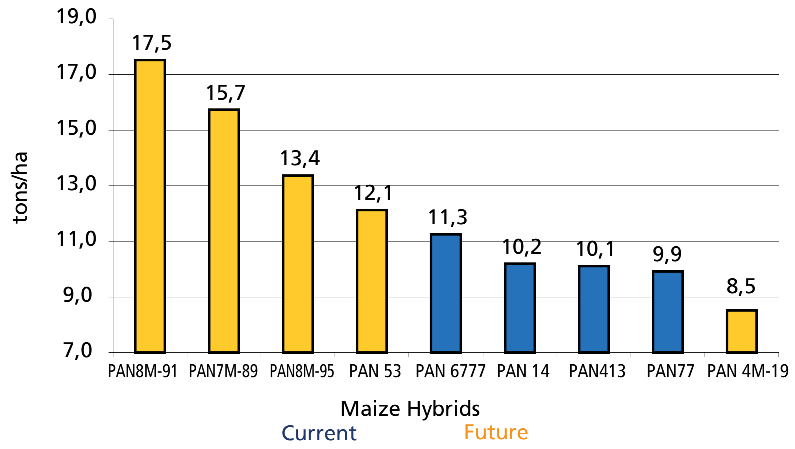


Fig. 6 Medium Rainfall - Commercial Hybrids



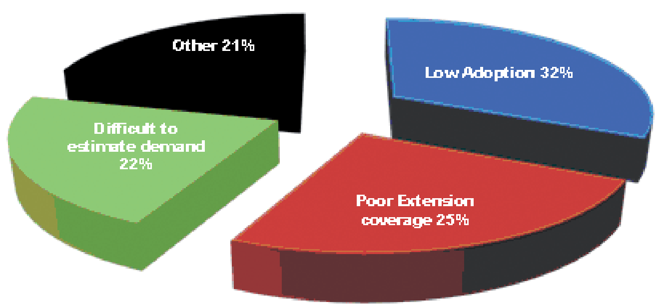
Low Seed Demand at Farm Level

It can safely be stated that, at its current level of development, the available germplasm is capable of producing enough food for the present world population. However, in developing countries which are now facing a food crisis, farmers are not readily adopting new improved varieties and are therefore being deprived of their benefits.

Fig. 7 shows low take-up of improved varieties in Eastern and Southern Africa. This is attributed to:

- Poor coverage by extension services and lack of up-to-date information on varieties and services available.
- Farmers are unaware of the availability of improved varieties that can increase productivity.
- Farmers make decisions without being aware of varietal characteristics.
- Seed companies are unable to forecast demand.
- Other factors such as poor access to credit and lucrative markets handicap farmers in the developing world.

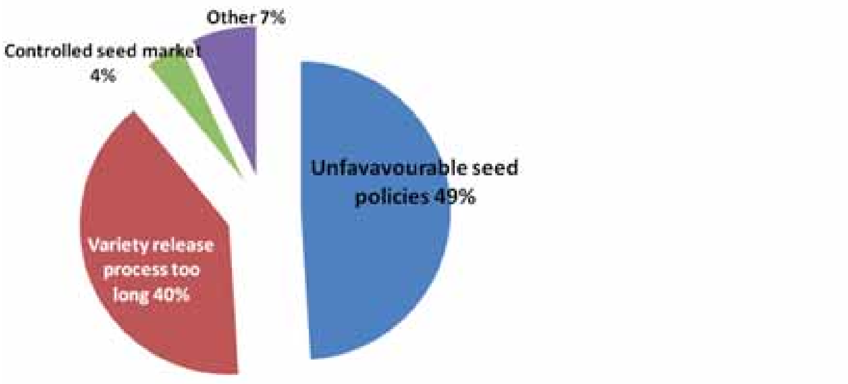
Fig. 7 Bottlenecks influencing Farm level seed demand



Seed Control and Certification Legislation

Seed policy or its absence has in many instances, particularly in developed countries, impacted negatively on development of the seed industry and agriculture in general. Fig. 8 illustrates the principal bottlenecks which limit seed production and distribution in Africa.

Fig. 8 Major Seed Policy Related Bottlenecks Hindering the production and distribution of seed in Africa (DTMA Seed sector survey 2007/8)



Few developing countries have well-defined seed policies to guide development: in many instances private seed companies are unable to use their performance trials as part of the official variety release process, and with the financial constraints experienced by many public agencies, this retards the speedy introduction of new varieties.

State control of seed markets is often regarded as protecting farmers' interests and national economies. Results have shown, however, that free trade works to the advantage of both the farmer and the national economy.

Few countries have established accreditation to important international organizations such as the Organisation for Economic Co-operation and Development (OECD), the International Seed Testing Association (ISTA), etc., and thereby experience difficulty in accessing international markets. (Table 1 shows the position in Eastern and Southern Africa while Table 2 shows the time lag before market release of a new variety.)

Table 1 Table no.1 Status of seed control legislation in Eastern and Southern Africa DTMA Seed sector survey 2007/8

	Seed Act	Plant Variety Protection	Variety Registration	ISTA Accreditation	OECD Accreditation
Eastern Africa					
Ethiopia	No	Yes	Yes	No	No
Kenya	Yes	Yes	Yes	Yes	Yes
Tanzania	Yes	Yes	Yes	No	No
Uganda	No	No	Yes	No	No
Southern Africa					
Angola	Yes	No	Yes	No	No
Malawi	Yes	No	Yes	Yes	Yes
Mozambique	Yes	Yes	Yes	No	No
South Africa	Yes	Yes	Yes	Yes	Yes
Zambia	Yes	Yes	Yes	Yes	Yes
Zimbabwe	Yes	Yes	Yes	Yes	Yes

Table 2 Length of seed release process in selected countries

	Actual time to seed release (years)			Time from release to time significa quantities of seed is available (years)		
Country	Mean	Minimum	Maximum	Mean	Minimum	Maxim
Kenya	3.1	1.5	6.0	2.4	0.0	9.0
Malawi	3.0	2.0	7.0	1.9	0.5	3.0
Tanzania	2.2	1.0	3.0	2.0	1.0	3.5
Uganda	2.2	1.0	4.0	2.1	1.0	4.0
Zambia	2.1	1.0	3.5	2.5	2.0	3.0
Zimbabwe	2.2	1.0	3.0	2.4	1.5	4.0
South Africa	2.0	2.0	2.0	2.5	2.0	3.0

Source: DTMA Seed sector survey 2007/8

Government and Donor Mindset

As stated earlier, there is adequate germplasm and information available for growers to produce enough food for the world's population.

The mindset of many governments in developing countries is not responsive to market demands, resulting in poor exploitation of natural, human and technological resources. In spite of the crucial role agriculture plays in national economies, there is too little investment in agriculture and research in the domain is often the lowest of national priorities!

Some donor agencies are not long-term development-oriented and often do not collaborate with local authorities. Valuable funds are spent on short-term relief which adds little value to long-term sustainable development. Governments and donor agencies should therefore adopt Ms Anderson's approach and focus on educating farmers and improving their operational efficiency by making available the right tools, information, finance and markets.

Conclusion

It is gratifying that seed stakeholders have mobilized to deal with anticipated demand and challenges to plant breeding and are trying to find a global response through the exchange of ideas such as is taking place at this 2nd World Seed Conference.

Developing countries should consider a change in mindset by placing emphasis on developing agriculture and adopting current and new technologies.

The adoption of progressive seed laws and regulations with effective harmonization of the seed trade will give farmers better access to improved seeds.

Public-private partnerships are not only essential but critical for the seed sector: the Indian sub-continent and South East Asia have seen a higher growth rate in agriculture mainly because of cooperation between the public and private sectors.

Discussion

FRANÇOIS BURGAUD (GNIS, FRANCE): I totally agree with the remarks of Marcel Kanungwe about the importance of the partnership between the public and private sector and especially in developing countries. I have two remarks and questions: First, I didn't take the floor earlier but I was surprised by the figure given by Marcel Bruins that the increase of yield has been the same in developing countries as in developed countries over the last 50 years. I think it would be interesting to enter into more detail on that because at least in some developing countries, of course in sub-Saharan countries, but also in some countries in South-East Asia, it is not the situation as I know it. The second is about the fact that Marcel Kanungwe said that it would be good to have good cooperation like in India. I would be interested to know the feelings of Mrs. Barwale about the cooperation between the public and private sector in India, because I have not the same feeling on that point. And mainly I have the impression that cooperation is in reality separation and the public sector is in charge of self-pollinated crops and the private sector is in charge of hybrids and vegetables. But maybe I'm wrong. And the last thing: I think it's really a big problem because the situation today is not at all about partnership. The situation today, especially today, is really that there is not much co-operation between the public and the private sector, and I know of very few partnerships, especially in breeding.

ORLANDO DE PONTI (ISF): You asked the question to Usha Barwale. I propose as this is an important issue, participation and collaboration public-private etc, I will move it to the general discussion at the end of the session because I think it is important to give it more attention than the limited amount of time that is left now.

EFFECTIVE USE OF MODERN BIOTECHNOLOGY, MOLECULAR BREEDING AND ASSOCIATED METHODS AS BREEDING TOOLS

Mrs. USHA BARWALE ZEHR*

Biotechnology has been at play since prehistoric times. Selection for visible phenotypes that facilitated the harvest and increased productivity led to the domestication of the first crop varieties and can be considered the earliest examples of biotechnology. The utilization of plant breeding methodologies has led to the development of improved varieties. The high yielding varieties of the green revolution transformed agriculture in many developing countries, providing an opportunity for farmers to improve crop harvests and livelihoods. During this time, some hybrids were also being cultivated around the world and more research started on a whole range of crops to exploit hybrid vigor. In general, productivity was improved by over 10 per cent in most crops and by much more in others.

Some of the most significant crops in the world, rice and wheat, being self-pollinated species could not be hybridized on a commercial scale. Research in these crops has also continued and today hybrid rice and hybrid wheat are being cultivated in many countries, keeping pace with production needs. As hybrids developed, critical factors relating to grain quality had to be met for the crop to be acceptable to consumers. The area under hybrid wheat and hybrid rice continues to grow. The utilization of genetic diversity has made this possible, and with the use of male sterile female parents, hybrid seed production became feasible. While the current hybridization systems in these two crops are making progress, continued effort in research is needed to find alternate male sterility sources as well as further diversification of the existing germplasm.

Self-pollinated species such as chickpea, pigeon pea, peanut and others have not benefited from some of these technological advances due to their inability to produce commercially viable hybrids.

The 1980s saw the modern plant biotechnology era begin with the first transgenic plants being produced in 1983, using Agrobacterium-mediated transformation. This was soon followed by the use of molecular marker systems for crop plants by creating high-resolution genetic maps. These two technologies presented, as never before, opportunities to understand and learn how genes can be transferred across species' barriers and how they function. Use of molecular markers was incorporated more and more in traditional breeding programs particularly in the private sector.

Molecular breeding

Technological advances in molecular breeding have been truly spectacular and the reason for this is in part due to the benefits that the technology provides. Molecular breeding exploits useful genetic diversity for crop improvement, offers greater precision and the efficiency of selection is enhanced. All of these factors are allowing for greater gains year-on-year which is reducing the time it takes to develop a new variety or hybrid.

Molecular breeding started with marker systems like the RFLPs where a limited number of markers could be tracked and the time taken was longer than the present day molecular systems which are moving more and more to SNP databases, allowing for whole genome selection, backcrossing programs, MAS and genetic analysis in general. The molecular marker systems are also critical in IP-related matters. Having a ready fingerprint of a proprietary line can be key in ensuring that the breeder's material is protected from illegal use.

* Director of Research, Mahyco, India

Molecular breeding can be most effective when good phenotyping is also available for the material. Combining the phenotype and the genotype serves to associate certain markers with a phenotype validating their use. Not all markers can be linked to phenotypes but they can still be used productively. In the case of rice for instance, it is possible to integrate all relevant bacterial leaf blight tolerance Xa genes into commercial parents ensuring that the hybrid is tolerant to this common disease. The markers are well defined and most products are moving towards having at least three Xa genes for durable tolerance. Similarly, a more challenging problem in rice is the brown plant hopper. Good phenotyping methods are available for screening the germplasm and also molecular markers have been identified which provide varying levels of tolerance.

Selecting the best germplasm based on the phenotype screening methods and then applying the knowledge of available molecular markers strengthens the probability of tolerance in the ultimate product. Also this overcomes some of the variations one may see in phenotype screening due to environmental factors. In the case of rice, there are many advantages in that the entire genome has been sequenced and a lot of information is available. The challenge for us is to translate this information into a usable format and to be able to address challenges like drought, salinity and yield per se. When looking at drought, for durable tolerance there is a need to address all the stages of drought the crop may be subject to such as seedling stage drought, pre- and post-flowering drought. Also, the need to find tolerant germplasm and the ability to do phenotyping in combination with the power of molecular breeding may ultimately give us plants which can tolerate drought stress better.

All of these molecular advances are allowing the plant breeder to accumulate more and more of the favorable alleles in the lines being developed, thus improving the genetic potential of the crop. All of these tools are available and ready to go. In some crops like maize, soybean, rice, tomato, to name a few, the use is extensive and growing. Much more work is needed in other crops and it must be applied more widely so more and more breeders can benefit from these technologies, ultimately leading to better product for farmers.

As molecular technologies advance, we continue to gain a better understanding of critical functions which lead, for example, to heterosis. Looking at expression profiles of parents and hybrids may shed some light on what valuable contributions are made by which line or what stages of plant growth have the greatest impact on hybrid vigor. This kind of understanding will allow breeders to become more precise on what elements to combine in the lines being developed.

Transgenic crops

This is another example of how biotechnology has impacted on agriculture in the last decade. The first question often asked is why there is a need for transgenic crops. Generally when there are no known sources of tolerance and the conventional approaches to date have not been successful, transgenic crops can provide an alternative approach to address the challenge faced by a certain crop. The first generation traits which have been commercialized have addressed the following;

- Insect-tolerant crops
- Herbicide-tolerant crops
- Disease-resistant crops

As technological advances are allowing us to address more complex traits, the transgenic crops in the product pipeline are addressing the following;

- Drought
- Salinity
- Fertilizer use
- Yield per se

Transgenic crops have changed how a crop is seen; taking the example of cotton in India, this particular sector has changed at farm and farmer levels, and has increased trade and foreign exchange earnings. At the farm level, productivity has gone up, net returns have increased and 50 per cent fewer pesticides have been used. At the farmer level, labor costs have gone down, exposure to pesticides has been reduced, making an overall positive impact on health. India has moved up to being the second largest producer of cotton in the world with the introduction of one single technology and changed to being a net exporter from being a net importer. The positive environmental impacts are also well documented. Similarly many examples are now available which address salinity, virus and insect problems and the list is endless. The future looks bright.

Conclusion

With the examples discussed here, it is clear that biotechnology is providing unprecedented options for enhancing plant breeding. Much progress has been made with some crops. This needs to be more rapidly adopted and implemented where it is not being used today and more work is needed on crops where the data available is limited. The technology itself holds enormous potential. Molecular breeding and transgenic crops will continue to play a key role in improving productivity in a sustainable manner, as has been seen in the last 15 years. The biotechnology revolution is underway, use of molecular tools and transgenic crops will allow us to meet our food needs in a sustained manner with limited availability of resources.

Discussion

JEAN PIERRE POSA (CHILEAN SEED ASSOCIATION ANPROS AND SEED ASSOCIATION OF THE AMERICAS SAA): Through these nice presentations we have seen that traditional breeding techniques and modern breeding techniques are really advancing breeding in the world. I do not really have a question, but my worry is that some of our companies and breeders are spending a lot of time dealing with basically regulatory issues, IP issues, probably more than they're worrying about traditional breeding or modern breeding techniques. Maybe that's a subject that somehow can be touched upon because there are still many countries where our breeders are really fighting the systems and basically becoming what I would call lawyers or agricultural bureaucrats, which makes breeding very difficult.

ORLANDO DE PONTI (ISF): I consider this just as a comment, and it's quite possible that you or somebody else would like to bring this back in the general discussion.

FRANÇOIS BURGAUD (GNIS, FRANCE): I would like to know if the breeding tools explained and used are patented in India and, if so, what is the cost for Mahyco to use these patented tools?

USHA BARWALE ZEHR (MAHYCO, INDIA): Indian patent law does provide for the ability to protect DNA at different levels, but it does not allow for protection of varieties. So at this moment as companies are developing new technologies, we are seeking to have greater clarity on what is protectable and what is not. We take account of the cost of the use of molecular markers as of any other cost in plant breeding. In some cases it is high, but only if the value that we get from it is also high are we eager to use it, because it would be under license if it does not belong to us. So there is a cost associated with it but this is relative to the benefit that we get.

THE OPPORTUNITIES PRESENTED BY MODERN BIOTECHNOLOGY TO ENHANCE PLANT BREEDING: WHAT'S IN THE PIPELINE? WHAT WILL DEFINE THE FUTURE?

Dr. WILLIAM S. NIEBUR*

Crop Genetics Research & Development

Plant breeders face a number of challenges to increase food supply and productivity compounded by a growing global population, a limited amount of arable land and numerous other issues around the world. However, this is an exciting time. Never before have we seen the convergence of so many new technologies that will allow us to develop more productive, more efficient crops more quickly than ever before. Biotech tools are allowing us to expand plant breeding programs, accelerate the rate of genetic gain, fully exploit native genes and bring new attributes to crop species.

In several crops and geographies, yields have increased significantly over recent decades. For example, corn productivity in the US has increased dramatically through a combination of new technologies and improved management practices. Those productivity increases, however, have not been seen on a global basis or across all crops.

Biotechnology is a critical tool to enhance plant breeding and meet the Pioneer goal of increasing corn and soybean yields by 40 per cent by the year 2018, which would effectively double the rate of genetic gain we've seen over the last decade.

Tools of Modern Plant Breeding

There are a number of tools and technologies, which, combined with our knowledge of crops and elite germplasm base, create two pathways to product development (see Fig.). These pathways are linked through our strong enabling technologies which allow us to move at will between them.

Both pathways are deeply grounded in genetic approaches, in which we assay for a trait and then discover the underlying genes. The left side shows the discovery of native traits, or the characterization and molecular isolation of genes that reside in the crop itself, although sometimes in wild relatives or in low yielding varieties. Delineation of these genes using mapping/molecular markers identifies genes that are necessary and sufficient for a trait. The right side shows discovery of transgenic traits, where we want to change the expression levels, location or timing of a gene, to add more power to a trait, or to use a gene from a different species, whether another plant or a microbe. This is also the pathway where we can apply genetic shuffling to dramatically alter and enhance the properties conferred by a gene.

Today, increasingly, both paths must come together to complete the package before a new product is developed. For example, molecular markers are used to identify and clone a native gene of interest, and then develop either a non-transgenic or transgenic product depending upon whether changes in gene regulation are or are not needed.

Mining existing germplasm for novel or rare alleles includes looking for opportunities to more fully exploit native variation, to shorten breeding cycles, and to get more genetic gain from each cycle of a breeding program through the precision of molecular breeding.

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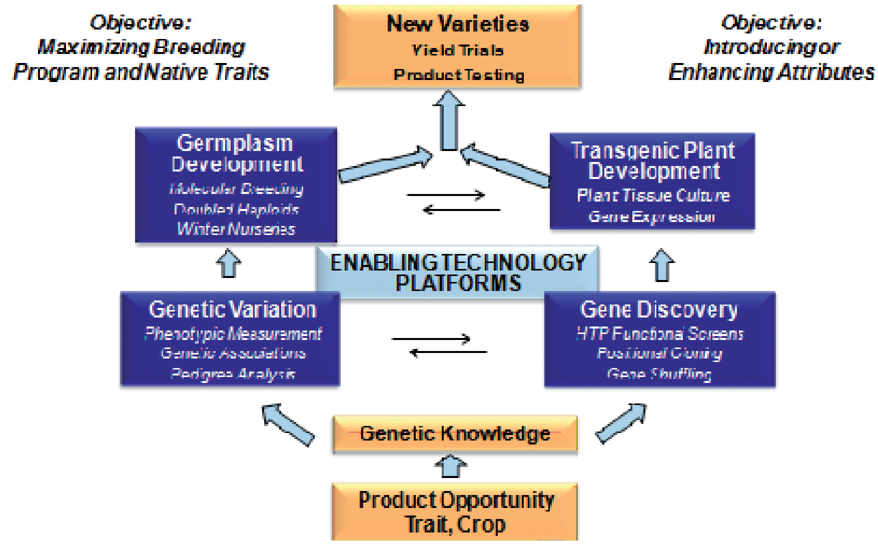
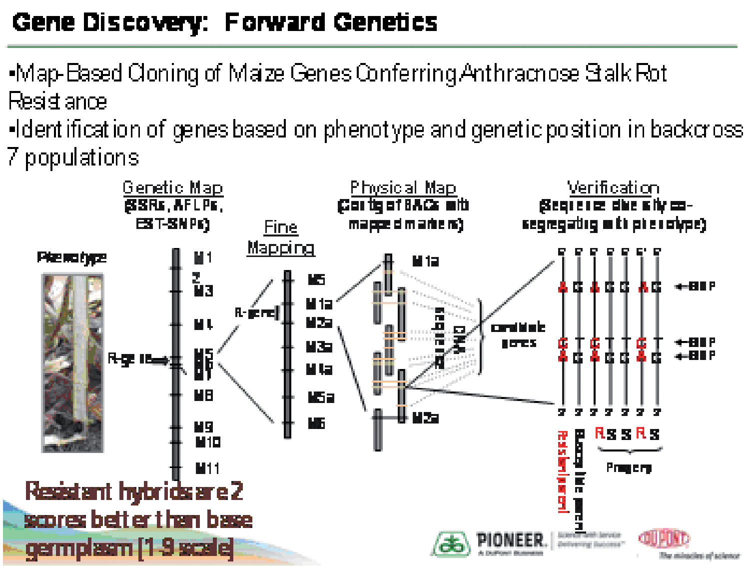
Fig 1 The tools of modern plant breeding



Our knowledge of the corn genome has increased exponentially with the advent of a number of specific technologies that allow quicker, more efficient analysis of the plant, including:

- Doubled haploids and molecular markers which allow the identification and characterization of more native genes than ever before.
- Laser-assisted seed selection which provides the ability to analyze an individual kernel to determine if it has the desired properties. Decisions can be made immediately without planting in the field and waiting for the next growing season. It is a fully automated seed sampling process for increased breeding accuracy and efficiency.
- At Pioneer, FAST (Functional Analysis System for Traits) corn is another example of using leading-edge technology to reduce the time it takes to identify and test potential leads for new traits. FAST corn is used to more quickly test agronomic expression of plant characteristics, such as water use efficiency or nitrogen use efficiency.

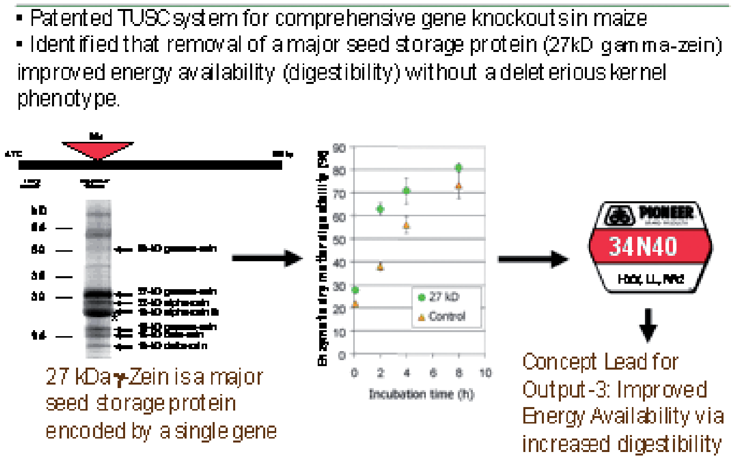
Fig 2 Gene discovery: forward genetics



Both forward genetics (see Fig. above) and reverse genetics (see Fig. below) are being used to introduce new attributes or enhance existing traits in the plant. Forward genetics seek to find the genetic basis of a phenotype or trait, then clone the sequences underlying a particular mutant phenotype. Reverse genetics seek to find the possible phenotypes that may derive from a specific genetic sequence obtained by DNA sequencing.

Native traits play a key role in enhancing yield by giving the plants the protection they need from diseases and pests, such as brittle snap, fungal diseases, aphids and nematode, and native traits can enhance a plant's tolerance for various stressors, such as cold and drought. Native genes have also been employed to improve nitrogen utilization and enhance grain quality.

Fig. 3 Trait discovery: Reverse genetics



Modern plant breeding is moving quickly away from the paradigm of native versus transgenic traits to integrating transgenic and native genetic diversity with genetic knowledge. Using all of these tools, new products can be developed with the strengths of both.

Finally, the sun never sets on plant breeding today. Vast networks of seed companies, governments, universities and other research centers are employing modern breeding and biotechnology to accelerate plant improvement on a multitude of crops around the globe.

Enhancing Productivity with New Products and Traits

The goal of all these technologies is simple – developing new hybrids or varieties that bring additional value to the world's farmers. By combining native and transgenic approaches, researchers around the world are working to develop solutions to growers' most critical agronomic challenges and unmet needs.

The following pipeline technologies represent several game-changing opportunities for yield gains by helping plants overcome stressors in their environment, such as drought. Others are much further out on the development timeline, but represent exciting opportunities that could change the way we approach crop production:

- Insect protection on more acres
- Multiple modes of glyphosate tolerance
- Pollen fertility control, hybrid production
- Improved fuel, food and feed value
- Drought tolerance – native and transgenic
- Carbon sequestration
- Nutrient use efficiency
- Disease resistance
- Transgenic yield enhancement
- Salinity tolerance
- Plant density, plant architecture
- Cold and frost tolerance

Finally, the development of these technologies is also dependent on continuing to break down barriers on a global basis, including addressing the regulatory environment and IP issues, promoting biotechnology acceptance and responding to the need for increased science and technological education and training.

Discussion

ORLANDO DE PONTI (ISF): You mentioned a lot of important developments, complex traits such as drought, yield etc. Listening to scientists and breeders in a variety of conferences I feel there is always quite an emphasis on the potential of molecular biology, molecular genetics. Do you feel that you can develop those complex traits without massive investment in disciplines like plant physiology, etc. and what is your opinion on how to get these complex traits to a higher potential?

BILL NIEBUR (PIONEER, US): We are hiring today disciplines and domains that we never imagined we would hire into our plant breeding community: statistical modelers, mathematicians, physicists in some cases and even musicians. We're hiring individuals with very diverse backgrounds who understand complex systems and what you've described in agronomic traits are truly complex systems. A single point intervention creates a perturbation in a very complex biological system that has all kinds of compensatory mechanisms. And what we're really challenged to do is to bring the physiology, the cell biology, the metabolic profiling and the biochemistry back into our plant breeding programs to be able to understand the variability that we're able to create in controlled environments via genetic intervention. And so, Mr. Chairman, as you've suggested, your average plant breeding company today looks very, very multidisciplinary, very, very cross-functional and what we're finding is that many of those skills are not resident in our organization but we build those relationships through collaborations with universities, regional agricultural institutions, as well as global private sector partners.

IR HINDARWATI (CENTER FOR PLANT VARIETY PROTECTION, INDONESIA): Do you have any program for plant genetic resource conservation? In my opinion, it should be divided equally. I believe you are initially exploring the genetics from the land and then you put in some technology to make a new variety. Do you have any program for equal treatment of the genetic resources and the exploration of genetics?

BILL NIEBUR (PIONEER, US): An excellent foundational question for every plant breeder. We know that the basis for long term gain in selection programs is dependent upon having access to germplasm diversity. We have invested heavily in re-sequencing nearly 20,000 genes across 1,500 different accessions today to be able to understand allelic variation, allelic number, gene forms in the foundational populations from teosinte for example and maize through all of the open-pollinated varieties and to what were the hybrids of the early parts of the last century. We're extensively looking at that as well in soybean, millet, sunflower, cotton and canola. We absolutely believe that the re-sequencing work that we're doing today, enables association genetics in these species and allows us to begin to unravel the genetic basis for most of the important traits that we're trying to improve; it's interesting, Arabidopsis becomes a very fast form of canola. I mean it's simply a plant that we can use to do gene discovery in one tenth of the time that it would take us to do that same gene discovery in a canola plant or an oilseed rape plant or a mustard plant. So, right to your point, we have mass collections of germplasm. I showed the molecular profiling that we're doing in maize. We're doing that same sort of profiling in multiple species. Absolutely, fundamentally important.

ZEWDIE BISHAW (ICARDA, SYRIA): My question is, as you know biotechnology is quite high cost and it requires quite a huge investment. If you look into the public breeding particularly in the developing countries, access to this type of technology or researching part of the technologies is quite expensive. How do you see the role of the multinational companies in providing this type of technology in some form of partnership, particularly in developing countries?

BILL NIEBUR (PIONEER, US): Great question, and really comes to the fundamental foundation of how we collectively advance rather than individually advance. I can always tell a plant breeder by their level of humility, and anyone who has been a plant breeder who finds himself humbled by the environment and by the challenges that we face. The investment that you talk about keeps us all very sober about what the possibilities are. The investments are huge. The requirements are huge. What we've chosen to do, I believe increasingly is, as an industry, play a role via the foundations, via the CG system, where I have the opportunity to participate in the private sector committee. We believe that the opportunity really comes through partnerships. In the last five years we have educated 10 African scientists on-molecular markers and transgenic technology and they are currently working in Africa but they did their studies and they did a one or two year sabbatical in our laboratories educating them on the modern technologies and then partnering with them in research programs to give them access. So what we're doing today is why we don't believe that every developing country in the world needs to develop the molecular marker capabilities; we have those capabilities and partners, and we can take the DNA. DNA is DNA. Be it from cowpea, chickpea, cassava or maize. And we can run it through our systems and I think with the opportunity of going forward to identify the problem, develop a project to address the problem, and then form a collaborative relationship to be able to make those enhancements, building infrastructure, creating intellectual capital in the environment in which we're working and driving genetic gain in that crop. And again, trying not to compete with one another but to solve the problem, to collaborate.

BUILDING CAPACITY FOR PLANT BREEDING IN DEVELOPING COUNTRIES

MR. ELCIO P. GUIMARÃES*

Introduction

Since the rediscovery of Mendel's laws early in the 20th century, the improved varieties planted by farmers worldwide have increasingly been developed by well-trained plant breeders, in contrast to farmer-developed varieties of previous eras. Breeders use knowledge about the crops, plant genetic resources conserved in gene banks, scientific breeding methodologies and tools, and effective seed delivery systems. Any disconnection or broken linkages in this chain result in lack of improved materials available to farmers.

Access to plant genetic resources, according to the experience reported by many countries,[1] became more difficult in the last decade. In general, plant breeding programs in developing countries worldwide have lessened their capacity to develop improved varieties, and seed delivery systems have deteriorated. In addition, soaring food prices up to 2008 and the resulting international economic situation have contributed to diminished potential to invest in the different elements of this technological chain. Increases in productivity and production remain well below their potential.

While recognizing the importance of all three major elements in this chain (plant genetic resources, breeding and seeds), this paper will focus on the plant breeding component. It will provide information on the worldwide assessment carried out by FAO to understand the plant-breeding capacity at national, regional and global levels; describe the development and functions of the Global Partnership Initiative for Plant Breeding Capacity Building (GIPB); and suggest how national capacity can be improved, including seed delivery systems. Also without discounting the great contribution of the private sector and the influence of the UPOV Convention in increased varietal development and dissemination activities, the aim of this paper is to focus on the activities of the public sector in this area.

Assessing the National Plant Breeding Capacity

Scientists working with plant genetic resources frequently comment that "plant breeding capacity worldwide is decreasing; the average age of the breeders is increasing as there are fewer young scientists being attracted to the field; biotechnology tools are becoming more easily available and are enhancing plant breeding; and the seed systems are being continuously weakened in many countries". In 2003, an article published in Nature (Knight, 2003) called the world's attention to this problem. In order to better understand the above statements and to produce data to substantiate or negate them, in 2002, FAO, and a large number of partners, including the CGIAR centers, started assessing the national plant breeding and related biotechnology capacity worldwide.

The national capacity assessment was made based on a questionnaire prepared to gather data on the following:

- the number of plant breeders[2] working in public and private sectors;
- the age of the plant breeders;
- the number of plant biotechnologists applying the tools on issues related to plant breeding in public and private sectors;
- the crops and/or crop groups under improvement;

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* GIPB team members at FAO, in collaboration with Mr. Clair Hershey, Mr. Eric Kueneman and Mrs. Michela Paganin, Italy.

[1] Country reports prepared by 109 countries worldwide on the "State of Plant Genetic Resources for Food and Agriculture" as contribution to the "second State of the World's Plant Genetic Resources for Food and Agriculture report" (SoW-2) to be presented to the Commission on Plant Genetic Resources for Food and Agriculture on October 19-23, 2009.

- the biotechnology tools used by the plant biotechnologists;
- the number of varieties released.

National consultants (generally plant breeders with broad experience in the target countries) carried out the survey. The information was gathered taking a five-year interval starting in 1985 and ending in the year of the survey. This series allows for drawing a trend curve for each set of data. To date more than 80 countries have replied to the questionnaire.

Based on survey data from Africa, Guimarães et al. (2006b) found that the number of plant breeders have increased in some countries since 1985, but the current numbers in many countries are still below the critical level that would allow for achieving the proposed national program's goals. The situation in Central Asia contrasts with that of Africa: even though similar declines were reported in many countries in the region, the number of breeders is still high enough to deliver improved varieties required by farmers (Guimarães et al., 2006a). In the Near East and North African regions the assessment suggested that the number of breeders is below the critical level (Guimarães et al., 2007). Nonetheless, in all three regions financial support for crop improvement declined significantly, impeding efficient crop improvement programs.

Frey (1996) surveyed the US plant scientists in the mid-1990s and found that crop improvement was largely a private venture, with twice as many breeders in the commercial sector as in universities and government agencies combined. In Brazil, Guimarães (2008) identified 467 plant breeders of which 35 were in the private sector and 214 worked at the Brazilian Agriculture Research Corporation (Embrapa), a public institution.

To house the results of the assessment carried out by FAO, GIPB created a database called "Plant Breeding and Related Biotechnology Capacity Assessment" (PBBC), which can be found at http://km.fao.org/gipb/pbbc. In addition to data on plant breeding capacity on PBBC, all reports prepared by the consultants are available, along with country briefs summarizing the key findings and suggesting actions to strengthen the national capacity.

Global Partnership Initiative for Plant Breeding Capacity Building

The downward trend in national capacities to utilize plant genetic resources for food and agriculture underscored the need for an international initiative in building plant breeding capacity. The results of the assessment of plant breeding and related biotechnology capacity worldwide provided strong indications that capacity building in plant breeding and related biotechnology is the key to strengthening the possibility for developing countries to promote and benefit from sustainable agricultural development. The limitations in trained scientific and technical personnel and institutional weaknesses within the plant breeding sector and in its links with genetic resources and seed delivery systems are key challenges that prevent the potential contribution of plant breeding to sustainable development to materialize more widely.

The GIPB was launched in Madrid in June 2006 at the time of the First Governing Body Meeting of the International Treaty on Plant Genetic Resources for Food and Agriculture and was proposed to enhance professional and institutional plant breeding capacity in support of crop production intensification, food security and sustainable development.

The GIPB was proposed as a partnership of public and private sector parties from both North and South, working in concert to enhance the capacity of developing countries to improve their agricultural productivity through sustainable use of plant genetic resources for food and agriculture.
The mission, vision and five longer-term objectives of the GIPB were defined through a consultative process aiming at the integrated enhancement of national plant breeding capacity building strategies for sustainable crop intensification and production system development. The GIPB (2008) Business Plan defines the mission as enhancing the capacity of developing countries to improve crops for food security and sustainable development through better plant breeding and delivery systems. The vision is described as the improvement in crop performance and food security based on the establishment of enhanced sustainable national plant breeding capacity. The five objectives are:

- Objective 1. Support policy development on plant breeding and associated scientific capacity building strategies, to help allocate resources to strengthen and sustain developing countries' capacity to use plant genetic resources for food and agriculture.
- Objective 2. Support education and training in plant breeding and related scientific capacities relevant to utilization of plant genetic resources.
- Objective 3. Facilitate access to technologies in the form of tools, methodologies, know-how and facilities for finding genetic solutions to crop constraints.
- Objective 4. Facilitate exchange of plant genetic resources, from public and private breeding programs, that can enhance the genetic and adaptability base of improved cultivars and production systems in developing countries.
- Objective 5. Share information, focused on plant breeding capacity building, to deliver newly available knowledge to national policy makers and breeders in developing country programs.

Lessons from the Regional Consultations

The GIPB is carrying out a second level of analysis beyond the country studies, to look at capacity at the regional level and to understand how capacity building might be made more effective and efficient when countries within a region collaborate. At the time of writing, these studies are at different levels of completion.

South and Southeast Asia.

Based on a review of the country surveys, as well as an online consultation among breeders in the region, five recommendations were elaborated:

1. To focus on training for efficient integration of molecular breeding tools into plant breeding research.
2. To train breeders in analysis techniques to set the right priorities for breeding in both the short-term and long-term.
3. To facilitate cooperation among institutes within a country and internationally, e.g. sharing of laboratories for biotechnology.
4. To develop a budgeting approach that allows for long-term investment rather than an annual budget cycle.
5. To set up a system for rewarding research stations for doing a good job providing the best planting materials to farmers.

Sub-Saharan Africa.

In most countries, breeding priorities have historically been skewed toward species of export value. As a result, priority is given to developing varieties, in the shortest time possible, that meet foreign market standards. In countries that have crop-specific institutes (e.g. Ethiopia, Ghana and Malawi) a large number of crops or crop groups tend to benefit from breeding. On the other hand, where plant breeding research is relatively new, there are only a few crops that benefit from breeding. The CGIAR centers constitute a major source of germplasm used in breeding programs in all the surveyed countries, particularly for crops within their respective mandates. While the number of breeders has increased somewhat throughout the region over the past 20 years, as well as their level of qualifications, there remains a major concern about the high staff turnover rate in most national plant breeding programs, mainly due to lack of incentives to retain the most qualified and competent staff. The lack of good financial records in many countries makes it difficult to make a good assessment of the national funding situation of agricultural research, as well as that from external sources.

Western Asia and North Africa.

The overall trend of declining plant breeding capacity appears to be clear from the survey results. Stagnant or reduced budgets and fewer released varieties have been recorded in the last 20 years. One of the principal factors underlying the problem of reduced funding faced by the public sector is lack of awareness among policy decision-makers on the impact of plant breeding on national development.

The public and private sectors often operate largely independently. Countries of the region need to promote training on both conventional and biotechnological tools, helping prepare project funding and facilitating germplasm exchange. However, this support will only be of value if these scientists co-ordinate action among themselves and with other disciplines in both the public and private sectors.

Latin America and the Caribbean. There is a wide diversity of situations in this hemisphere with regard to the capacity of plant breeding programs, much of it related to the size of the country, and, consequently, the size of the agricultural sector and its ability to invest in plant breeding and biotechnology. The under-investment in plant breeding and associated technologies is evident in both human resources and physical resources, and it cuts across both public and private sectors. A main challenge for motivating the participation of the private sector is the relatively small size of the market. In view of this, the two-tier debate is whether each country should have its own seed market or be involved in regional or international seed markets. In taking these decisions, these countries need to ask themselves how much yield potential they are giving up by not being fully able to breed for local conditions or access improved varieties suited to their agro-ecological conditions. A further argument relates to the cost-benefit rationale as well as profitability of home-grown seed in contrast to imported seed.

Factors Limiting Success

After all the resources are assessed, and considered in combination, it is possible to better determine the factors that limit success of breeding in a program. At this stage, the surveys enter into a more subjective area, as compared to the hard figures on institutional and personnel resources. In the 15 to 20-year period of the survey coverage, there is relatively high consistency in the important limitations, especially those at the top of the list. Table 1 summarizes the limitations perceived by scientists and research administrators on a regional and global basis. Interestingly, in spite of the decline in resources available for plant breeders, the lack of financial resources to carry out field and laboratory experiments ranked only seventh in importance as a constraint limiting success in plant breeding programs. Nonetheless, this lack of financial resources would also be reflected in other areas of capacity. From the survey, five limiting factors stand out at the global level (in order of importance):

- Inadequate experimental field conditions
- Inadequate number of breeders for each crop
- Inadequate access to recent literature
- Inadequate knowledge level of the general plant breeding strategies
- Limited access to international genetic resources

While there is general consistency among regions, there are also a few marked regional differences. For example, "inadequate number of breeders" is ranked first in Asia, but only at a medium level of importance in the Americas and in Africa. "Inadequate knowledge level of general plant breeding strategies" is ranked first in Africa, but only given a medium level of importance in Asia and the Americas. "Limited access to international genetic resources" is a very important constraint in Africa and the Americas, but of only medium importance in Asia.

The implications for these results are that capacity building should be defined and carried out in a systematic manner that takes into account both the unique needs of a country or region, but at the same time should make use of the efficiencies that can be gained by the common needs across countries and regions. Of the top five priorities at the global level, it appears that perhaps only "access to international genetic resources" may show a relatively low importance in Asia, while the other priorities can be understood to be of at least moderately high importance across developing countries.

These top-ranked priorities include all the elements of the GIPB priorities and goals relating to policy, education and training, access to technology, access to genetic resources and sharing of knowledge and information. They indicate that in order to have optimal impact on capacity for crop improvement, a comprehensive approach is necessary.

Even though lack of mechanisms to stimulate private sector investments was not listed among the top priorities, countries in all regions recognized the need to have adequate national legislation to allow private sector investment in plant breeding. Some of them stated that public/private partnership is necessary to motivate efforts on crops that may not be as economically attractive as the major food crops.

Strategies to Build National Capacity in Developing Countries

In order to establish an effective national strategy to use plant genetic resources in developing countries, it is key to stimulate traditional plant breeding along with the application of biotechnology tools and to ensure that effective seed delivery systems are in place. There is no single strategy to achieve this, but it is relevant to consider the following general recommendations:

- To elaborate and maintain a pragmatic national strategy for food production, taking into account internal and external markets.
- To develop public awareness about the importance of plant genetic resources and their use and impact on crops and food production, including the seed delivery systems.
- To establish a mechanism to ensure harmony among the goals of plant breeding research and the application of biotechnology tools.
- To have in place mechanisms that ensure strong linkages among plant genetic resources, plant breeding and seed delivery systems.
- To have in place instruments to stimulate private sector investment and public/private partnerships.

Policy makers responsible for providing support to national programs working with crop improvement must be clear in their minds that an effective strategy requires investment from governments. Success entails long-term financial commitment because breeding a new variety and delivering it to farmers often takes more than 10 years.

Conclusions

Capacities in plant breeding, including both conventional and modern technologies, in most developing countries are neither sufficient nor properly integrated to fully capture the benefits of the plant genetic resources that are conserved. The lack of long-term support for national breeding strategies and programs leads to a lack of effective access to germplasm and technologies, especially biotechnology. In general, biotechnology work is done at universities without links with plant breeding programs. The limitations in trained personnel, institutional weaknesses and inefficiencies, both within the plant breeding sector and in its links with seed systems, are key elements that prevent the potential contribution of plant breeding to food security and for sustainable development to materialize. Mechanisms to promote public and private partnerships are also crucial to the success of national strategies to improve crops. This leads to under-developed seed systems and to poor transfer of improved germplasm to rural producers.

Raising the capacity of plant breeding at national and regional levels requires the training of more plant breeders and the development of an integrated set of capabilities and support systems to build and sustain effective national and regional plant breeding capacities. At the same time, dealing with the resulting increase in crop productivity and in supply, processing and distribution of agricultural commodities can make an important contribution to further improving food and nutrition security and to the livelihoods of small scale producers, providing a source of increased production diversification, income and employment opportunity in the entire food chain. These facts need to be taken into account by governments and development organizations in formulating development strategies

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Table 1 Limiting Factors for Success in Plant Breeding Programs by Region, 2001/2005, as registered in Survey Results

	Ranking by region [1]															
Limiting factors	Caribbean	Central America	South America	West Africa	Eastern Africa	Middle Africa	Northern Africa	Central Asia	SE Asia	S Asia	West Asia	Overall Average	Americas rank	Africa rank	Asia rank	Overall rank
Inadequate experimental fields conditions	0	5	5	5	0	0	3	4	4	4	4	3,1	1	3	2	1
Inadequate number of breeders for each crop	5	0	0	1	1	1	4	5	5	5	5	2,9	4	5	1	2
Inadequate access to recent literature	0	4	4	0	5	3	0	3	3	3	3	2,5	3	4	3	3
Inadequate knowledge level of the general plant breeding strategies	0	3	0	4	4	5	2	0	2	2	2	2,2	5	1	4	4
Limited access to international genetic resources	4	2	3	3	3	0	5	0	1	0	0	1,9	2	2	7	5
Lack of knowledge about the use of molecular techniques to support plant breeding programs	2	0	0	0	0	4	0	1	0	0	1	0,7	8	6	6	6
Lack of knowledge about participatory plant breeding techniques	0	1	2	2	0	0	0	2	0	1	0	0,7	6	8	5	7
Lack of financial resources to carry out field and laboratory experiments	0	0	0	0	2	2	0	0	0	0	0	0,4	11	7	8	8
Limited access to national public and/or private genetic resources	3	0	0	0	0	0	0	0	0	0	0	0,3	7	10	9	9
Inadequate availability of laboratory infrastructure to carry out experiments using advanced plant breeding techniques	1	0	0	0	0	0	1	0	0	0	0	0,2	9	9	10	10
Lack of support from the international community, including organizations like Centres of CGIAR system, FAO, etc.	0	0	1	0	0	0	0	0	0	0	0	0,1	10	11	11	11

[1] Top five factors, by region (5=most important; non-ranked constraints assigned value of zero)
Source: *http://km.fao.org/gipb/pbbc*.

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Discussion

ZHEN LIU (WAGENINGEN UNIVERSITY, THE NETHERLANDS): You have mentioned so many times the public private partnership. Can you share some good stories to stimulate public private partnerships with us?

ELCIO GUIMARAES (FAO): There are many stories that would tell of how a good relationship between the public and private sector is important. With this initiative, in the GIPB, we do have on our site some examples of how the public and private partnership is taken on board by some countries and how it is producing results, so I don't want to pinpoint any specific example here, but there are many in different countries with different crops where it has shown that linkage and produced good results. The important point here is to understand that both have to benefit. We don't want to go into a partnership where one will take advantage of the other or vice versa. We have to understand the word "partnership". It requires benefits for both sides. And this is what we have been documenting on our GIPB website. If you go into the site that I have just mentioned, you will find some of the examples.

ADELAIDA HARRIES (IOWA STATE UNIVERSITY, US): I want to know if in your survey you have had any answer from the public breeding sector that one mechanism to promote public breeding and also private partnership is establishing the IP system in developing countries.

ELCIO GUIMARAES (FAO): Yes, again it's the same question. There are several examples where you find this type of partnership. And IP is not a limitation for a partnership contract. It's a stimulus for a partnership. It depends how you deal with IP rights in order to provide a benefit for both cases. I don't see any limitation in having IP issues considered when you deal with the public and private partnership. I'm from Brazil and in Brazil, Embrapa has several examples of partnerships made with multinational companies where genes from the companies are being used by the public sector in their breeding programs and IP issues are considered to be no problem at all. So again, there are many examples in this case and I don't see it as a limitation for stimulating partnership contracts. It should be a mechanism for stimulating partnerships.

CHRISTOPH HERRLINGER (GERMAN PLANT BREEDERS ASSOCIATION BDP): The issue of capacity building is an integral part of the International Treaty on Plant Genetic Resources for Food and Agriculture and I would like to know a little bit more or to learn a little bit about the role the International Treaty has played in improving this situation and what can still be done.

ELCIO GUIMARAES (FAO): As you know the Treaty is a new instrument and is being seen right now from the beginning of the implementation of the Treaty. Art. 14 of the Treaty deals with the Global Plan of Action and there are five major priority areas in the Global Plan of Action dealing with capacity building, so I see in the near future the International Treaty as a very important instrument to contribute to strengthening national capacity. Right now as I have said is just the beginning of that process and I don't think that it is time for us to evaluate whether it's producing results or not. But there is no doubt that it is an instrument that contributes strongly, and is strengthening capacity in all different areas, not only in plant breeding, but also in conservation and also related to seed delivery systems.

FRANÇOIS BURGAUD (GNIS, FRANCE): I think that we agree about the basic proposal in the last report. But we can't agree with the conclusions because when you say that there is a lack of mechanisms to promote public and private partnership it is not true. The truth is that there are a lot of mechanisms to avoid partnerships between the public and private sector. And my problem is I don't see how the FAO, which hasn't succeeded in improving the seed sectors and plant breeding in the last 40 years, would have a new chance. Bernard Le Buanec said that we have to take account of a new paradigm: I want to know what the new paradigm in FAO is that will change the situation. And I just give a few examples: FAO has implemented a lot of projects in seeds following the G8 and G20 about the food crisis. A lot of these projects in Africa were implemented without any consultation of the private seed sector of the countries which are concerned by these projects. These projects were financed by the

European Union. No discussion at all existed between the European Union, the Commission and the European seed sector about these projects. So it was decided some months ago, some weeks ago, maybe yesterday and there was no change in the policy on that. So I would really like to know what you are thinking of to implement, to change totally the relationship between FAO and the private sector.

ELCIO GUIMARAES (FAO): That is a very tough question for me and I'm calling on my directors. Well first of all I have to disagree with you. I don't think that your statement regarding what FAO has done or has not done is fully correct. You are looking at it from a different angle, so I would like to ask you to allow me to disagree with you on that. The second part is that the International Treaty and all the instruments that have been put into place in countries like your country are being seen as instruments that would allow FAO to act in areas such as plant breeding, such as the seed system and conservation to improve the situation. And you as a member country of FAO have the power in your hands to tell FAO how you want it to handle those issues. Obviously the issue of public-private partnerships within FAO is not a very easy issue to deal with but, again, FAO does not belong to me, FAO belongs to you and your countries so it is up to you and your countries to tell FAO how these issues have to be dealt with and I'm not in a position to defend either side A or side B. What I am in a position to say here is that according to the assessment that we have been making there is a very great demand for strengthening that relationship. If there are mechanisms available for that, let's use them. What I showed you is not what I am doing but what FAO has identified through the survey. The countries that were surveyed told us that the mechanisms are lacking. So that's the message they're seeing from us. So we can change that. So let's do it together and a forum like this is a good opportunity. And I would like you to think about this in the considerations that you are going to make on Thursday.

General Discussion

ORLANDO DE PONTI (ISF): I think this discussion is a very nice bridge to the next part of the program, the general discussion. By the end of the session I will make a summary of what we have learned this morning but before doing so I think it's important also to get some more perceptions of the variety of opinions in the audience. You have listened to five eloquent speakers on all aspects of the complex art of plant breeding. Feel free to ask any question as it is important for us, in these two days and the panel discussion on Thursday to improve our understanding in order to do an even better job in the 10 years ahead. So who wants to take the floor in this general discussion?

MICHAEL LARINDE (FAO): I would just like to go back to the last question, raised by Mr. Burgaud. And I wish to point out that the picture presented is not exactly representative, because some years back FAO started going bottom-top in our policy towards seed. In fact this Conference is evidence of that, because you rarely saw in the past all the five organizations involved here working together towards one goal. And we've done it here. This is one example. This shows changing policy, realizing that private-public partnership is very important and I think FAO is doing that right now. Another example is our work on seed policies, even in African countries, and the most recent at the congress at the African continental level, the African Seed and Biotechnology program which includes everybody, public, private sectors, CG centers, all stakeholders together in a forum to decide how best to move forward to having the same seed policy, to having the same seed activities for Africa. And I must say that we have countries which are very good examples of this: Afghanistan is one. From nothing, from an emergency situation they have built up a very good seed system and we did not stop there: we formed private seed enterprises. Now we have 32 of them. And we are doing similar work in other countries, so the picture is not totally correct. We have not got there yet, but we are moving towards that goal.

FLORA MPANJU (AFRICAN REGIONAL INTELLECTUAL PROPERTY ORGANIZATION): I listened to the previous speaker when he said that plant breeders were disappearing. In Africa the plant breeders rights were not even known, but thanks to GNIS, UPOV and ARIPO, they have got an initiative already. We have had a first meeting for Africans to sensitize themselves about plant breeders rights and that meeting was very successful, and I think Isabel can comment on it: at least we are doing something. We are trying to create the awareness, and we are trying to put plant breeders rights mechanisms in place so that even the private sector, when it arrives, will be protected. So the structure is there. Thank you to GNIS for the second time. My being here is because of GNIS. They have done a lot of things, so whatever the boss is saying is right. There is something going on.

HOSEA SITIENEI (KENYA SEED COMPANY LTD., KENYA): I think that the presentations have been quite excellent. I have two simple questions. I believe we all agree that any new technology has both negative and positive consequences. We've heard about the positives of the new technology. Do we have any negative consequences, in terms of health of the human being, and the environment? That is the first question. The second one is that we have all agreed that the cost of these new technologies is quite high and my worry is that the seed sector globally is going to be dominated by the multinationals and seed is going to be very expensive especially for the farmers in the Third World. Does FAO have any plans to intervene to make seed affordable for the majority of the farmers, especially in developing countries? Because seed is going to be very expensive.

BILL NIEBUR (PIONEER, US): I agree that these are absolutely critically important questions as we stand here today and consider the opportunities. What we know is that plant breeding is an art that has been practiced for many, many decades and what we know today is that we have improved varieties for their nutritional quality, their productivity and their ability to feed a hungry population. We know that the new interventions that we're bringing forth on the regulated side with the novel regulations are being tested in a much more extensive way than anything that we have ever released previously in our history. Well, that doesn't guarantee that there won't be a moment in time in the future. What we know is that hunger is present with us today, starvation is present with us today and the need for increased agricultural productivity is fundamental, primordial, if we are to stabilize the global situation. So we're continuing to invest heavily in the appropriate studies to understand the safety, the productivity and the consequences as we go forward. On your point: we continue to support that regulation because we believe it's the right thing. I think about the second point: the cost is high and that's why the private sector is investing today very aggressively but whether it is in computers, or television or communications, costs go down with time. And what we want to do is to continue to drive the cost. The scale of the programs that we've described here today is only possible because we have reduced the costs involved in conducting that technology. And increasingly it becomes relatively straightforward to utilize that technology and what we know is that the participative plant breeding that will go on in West Africa, East Africa, Sub-Saharan Africa, or in general on the sub-continent, will be augmented through these new technologies. But the fundamental need is for the people in the field, looking at the plants ensuring the quality is there; it has never been more important, than it is today. So what I believe is that we'll continue to drive the cost out of the system, we'll continue to drive the regulation, in a more sensible, more straightforward, more predictable manner. Then what we'll do is work with you on what is not really brought up today which is even more critical and this is 'stewardship and beyond': how we steward this technology in a responsible and sustainable way.

USHA BARWALE ZEHR (MAHYCO, INDIA): The only other point that I wanted to add to what Bill has already covered is relating to the costs and the need for a strong public sector. I think the costs are high but they are not prohibitive for the public sector to invest in so that the public sector program is complementary to the private sector program and together they can set up partnerships and bring better products.

ORLANDO DE PONTI (ISF): I would like to follow up because this is an important item, and it is related to a remark by Bill in his presentation, because technology and IP go together due to the huge investments. By the way, this is also evident from the slides presented by Bernard and Marcel; plant breeding always has been very expensive. That's the reason we saw this steep increase in yield only when there was protection of the product. That first started as we have seen and as we know, by the UPOV Convention in 1961. Later on and I would say, because of the advent of biotechnology, we got another system in our industry, that is utility patents. And another very important issue in plant breeding around the world over many, many decades is what I call access for further breeding. So I would like to know what Bill's opinion is on access for further breeding if we are talking patents.

BILL NIEBUR (PIONEER, US): Absolutely, an important question to address and I think that some of the other points in the sessions over the next few days will also address this. I believe that patents have a role to play in certain markets around the world, to foster and increase investment as we go forward in innovation. What we've seen is that where we have a combination of appropriate levels of intellectual property protection, be it plant variety, be it patents, utility or functional process patents, combined with trade secrets, what we find is that we drive genetic gain more effectively and more quickly. And so I believe that a reasonable approach to IP is one that considers the development of the market, considers the development of the industry, and that then allows those participants to be rewarded for the invention and the innovation that they have created. And so really I am absolutely a strong proponent of patents. I don't believe they are appropriate globally. I believe they have a place and a role to play, as do other mechanisms of intellectual property protection.

ISMAHANE ELOUAFI (CANADIAN FOOD INSPECTION AGENCY): I have got a question for Usha and Bill. It is regarding using genetic transformation for complex characters like drought and salt. I am not disputing whatsoever the importance of biotechnology or molecular biology. I am a molecular biologist myself, and I do believe it will help us to breed better crops for the future and it will speed up the process as has been shown for characteristics like resistance where you have a gene-for-gene relationship, but I am asking how realistic it is to pursue research or genetic transformation for drought and salt when we know it is very complex, it's multiple genes, it is minor effects and additives that we have there. So I'm just wondering how much is realistic to do at the public level mostly because I think we need a huge database to do it. Maybe at the private level it will be much more feasible.

USHA BARWALE ZEHR (MAHYCO, INDIA): Drought is a very complex trait and I think as we understand more and more about the different genes and the roles that they play, genetic transformation becomes one mechanism by which we can incorporate some of those genes. I don't think we're going to have a crop which is 100 per cent drought-resistant. Our goal is to improve what levels of resistance or tolerance we have today. Even if it means improving tolerance by 50 per cent of the levels that exist today, and genetic transformation is just one component of that not the only mechanism that will give us the ultimate product.

BILL NIEBUR (PIONEER, US): I think Usha has really captured it well. We really don't see it as one or the other. We really see the approaches as being very complementary. If we look at the maize hybrids that are grown today, our data would suggest they're four times more efficient at utilizing an inch of water in a water-limited environment than the hybrids of the 1980s or the 1990s. And that has really come through effective plant breeding. Our transgenic interventions allow us to change hormonal balance, water-storage mechanisms, plant-sensing mechanisms in shock proteins, and what we're actually seeing as an industry is that we're able to condition the plant to withstand transient water stress. Now what we have to recognize is that it rains, and no farmer wants to have a limit on the amount of productivity that can be realized due to the fact that he or she is carrying a drought-tolerance gene. And so we're really being very, very careful to also study how we supplement plant productivity in rain-fed systems as well as irrigated systems because in many parts of the world, the issue is not rain-fed or irrigated, it's that we're irrigating five times a year, how can we go to two? How can we actually move to a rice production system that irrigates rather than floods? And how can we go to a direct seeded rice situation where we would enable the seed quality and the hybrid vigor to allow it to establish a stand against weeds and not need water to control weeds, and to be able to use water more effectively? So there are a number of opportunities on the agronomic traits that we're pursuing in combination. Not one or the other. But I actually believe very strongly that molecular biology has much to offer.

ORLANDO DE PONTI (ISF): It's very clear that we all, as we are here together discussing plant breeding, want to contribute to the increasing needs of food for everybody. And it's clear that improved varieties will contribute a lot in creating productive agriculture. Agriculture starts with preparing the field, with planting the seed. The better the seed genetically, the better the potential for a good crop; of extreme importance in developing countries. I'm very happy this has been recognized again after being neglected for a period of about 20 years, as has been mentioned by the World Bank. It's also clear from the presentations that plant breeding, with contributions from public and private breeding and the collaboration between public and private breeding, has contributed a lot over the last 50 years. We've learned the percentages and also the various traits like resistance, tolerance, nutritional value etc. It's very important from what I summarize from the presentations where the plateau has been mentioned, and was very clearly mentioned by Marcel Bruins that from the breeding side we believe this increase is still there. There are a lot of rumors around in the world that plant breeding is getting to a plateau. As far as I know from my own experience, no matter what crop we're talking, there is still a steady increase of about 1 per cent per year through genetic improvement. You don't see it so clearly year-by-year but if you take 10 years there is a very clear difference. And it has been very well documented by many of today's presenters.

It means that by continuing our investment, and I say it again, public-private together, we will be able to significantly contribute to the alleviation of hunger and to have a better and more balanced right on food by 2050, when we share this world with more than 9 billion people.

From the historic overviews we have seen it is very clear that intellectual property is important: these were very nice slides. From the moment you start to protect the activities of plant breeding, you see immediately an increase in investment, no matter whether this is in conventional breeding, molecular breeding, whatever we call it, in any technology that brings the potential to a higher level, there is investment; from the public sector as well as from the private sector, but then you should have that possibility. This is very clear right from the start of the protection of plant varieties, somewhere in the middle of the last century. In addition to that, I want to make it very clear, there is of course a need also for utility patent protection for return on investment on different types of technology which contribute to the success of plant breeding.

Yes, there are still many tools in the pipeline. We've seen several of them: it is a fascinating toolbox. It is fascinating today to be a plant breeder and to work in a team with probably 10 different types of scientist and other skilled people in order to manage this complex game of recombining genes and technology, etc.

It has been mentioned only very briefly because there is an emphasis on plant breeding and on genetics in the most novel way, but it was mentioned by Marcel in his overview, that there is another technology that is showing increasing potential for the seed industry and this is seed coating, seed treatment, etc. In my view as a seedsman, in terms of seed treatment, seed coating, we're just at the beginning. I have a strong belief that there's a lot of potential. And be assured if you bring the best genetics with the best seed to the farmer you make him or her very, very happy.

The last point is that it is getting more and more complex: I would say it is getting more and more exciting. It is a fascinating field and I hope that we can encourage young people to go into plant breeding, and I really mean plant breeding. I don't mean plant biotechnology, I don't mean bioinformatics, so the more fashionable parts of plant breeding. There are students in the US, in Europe, in India etc. But what we need, we always will need, are plant breeders that are able to make the final selections, to do the final work in the field. Because whatever technology we have, in the end, the best variety is selected by the plant breeder in the field. And the plant breeder is the one, in my view who drives the machinery for improving and getting better varieties.

Session 1. Conclusion, presented by the Chairperson
The role of plant breeding in meeting the multiple challenges of a fast-changing world

- Improved varieties and high quality seeds are basic requirements for productive agriculture, which is the basis of sustainable economic development in developing economies

- Through the efforts of both the public and private sectors, plant breeding has provided an enormous contribution to global agriculture (yield, resistance to biotic stresses, tolerance to abiotic stresses, harvest security, quality traits including nutritional value, etcetera)

- Plant breeding has the ability to significantly contribute in solutions to several of the challenges ahead such as food security, hunger alleviation, increasing nutritional values, and higher input costs Plant breeding and related disciplines and technologies help in mitigating the effects of population growth, climate change and other social and physical challenges

- Intellectual property protection is crucial for a sustainable contribution of plant breeding and seed supply There are still many tools and traits in the pipeline that will prove to be very necessary for the continued supply of high quality varieties and seeds

- Apart from genetic enhancement, other technologies, e.g. quality seed production and seed treatments, contribute substantially to improved seeds, and capacity building in all these areas is urgently needed in developing countries.

Session 2

THE IMPORTANCE OF PLANT GENETIC RESOURCES FOR PLANT BREEDING; ACCESS AND BENEFIT SHARING

Chairperson: Mr. BERT VISSER,
Director Centre for Genetic Resources, Wageningen University and Research Centre (The Netherlands)

- **The use of plant genetic resources in plant breeding**
  Ms. ANKE VAN DEN HURK, Dutch Seed Trade Association Plantum (The Netherlands)
- **Facilitating access and ensuring benefit sharing globally: the Multilateral System of the International Treaty on PGRFA (ITPGRFA)**
  Ms. COSIMA HUFLER, Chair of the Governing Body of the ITPGRFA
- **Exchanging material in the daily business: the operations of the Multilateral System and the Standard Material Transfer Agreement (SMTA)**
  Mr. SHAKEEL BHATTI, Secretary of the ITPGRFA
- **Working with the Multilateral System: experiences of a seed company – representatives from private sector**
  Mr. JOEP LAMBALK, Director Enza Zaden R&D B.V. (The Netherlands)
- **Implementing the International Treaty at the national level: what is the impact on the seed sector?**
  Ms. YLVA TILANDER, Deputy Director, Ministry of Agriculture (Sweden)

General discussion

Conclusion, presented by the Chairperson

THE USE OF GENETIC RESOURCES IN PLANT BREEDING

Ms ANKE VAN DEN HURK*

In this paper the relationship between plant genetic resources and plant breeding is described. Furthermore, we explain how the existing balance between the two has changed since the ratification of the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA).

Plant Breeding

Plant breeding is described in various ways as can be seen in Box 1.

Box 1 Definitions of Plant Breeding

Plant breeding is the art and science of changing the genetics of plants for the benefit of humankind.
http://en.wikipedia.org/wiki/Plant_breeding

Plant breeding is the use of techniques involving crossing plants to produce varieties with particular characteristics (traits), which are carried in the genes of the plants and passed on to future plant generations.
http://www.ers.usda.gov/Briefing/Biotechnology/glossary.htm

Plant breeding is the purposeful manipulation of plant species in order to create desired genotypes and phenotypes for specific purposes, such as food production, forestry, and horticulture.
http://en.citizendium.org/wiki/Plant_breeding

It does not matter how plant breeding is described, all definitions have one thing in common; genes are recombined either through selection, crossing or other breeding techniques using genetic resources and resulting again in genetic resources.

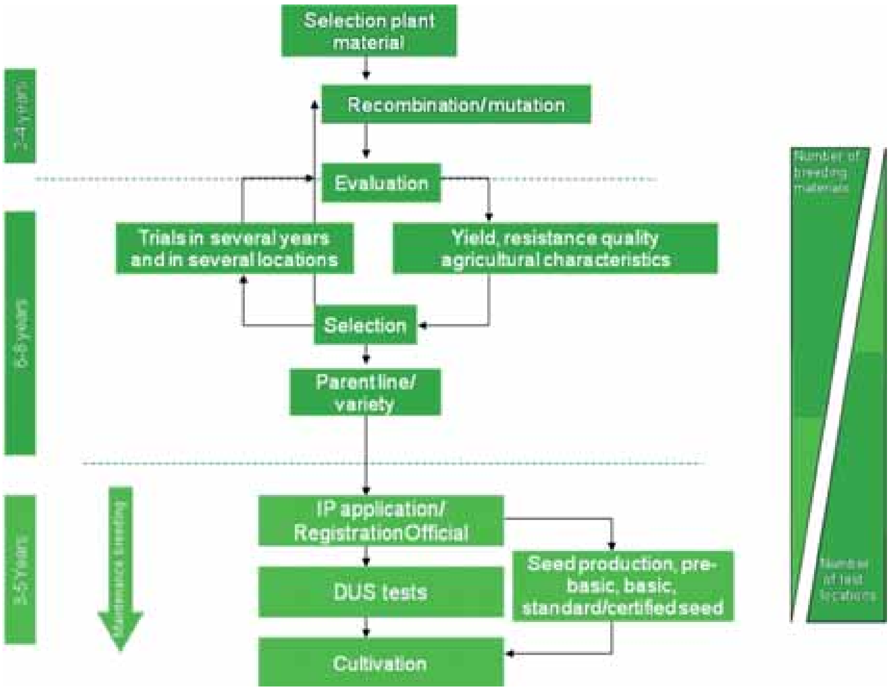
In Fig. 1 the process of plant breeding is described. This process can be divided into three major phases: 1. Recombination; 2. Selection; 3. Registration and Commercialization.

The recombination phase is used to try and get all the preferred genes together in the starting material of the breeding process, be it through mutations, crossing or other more advanced techniques. This may take from two to four years.

Once the genes are put together, the selection process starts. During this phase the best combination of genes is selected in such a way that it becomes stable either as a variety or through parent lines. The selection procedure is long and tedious and may take from six to eight years. At the beginning of the breeding process, selection is done in one place, but later on in the selection it takes place at other locations to see if the material is adapted to the climate and meets the needs of the different farmers and/or growers.

* Dutch Seed Trade Association Plantum, The Netherlands

Fig. 1 Plant Breeding Scheme



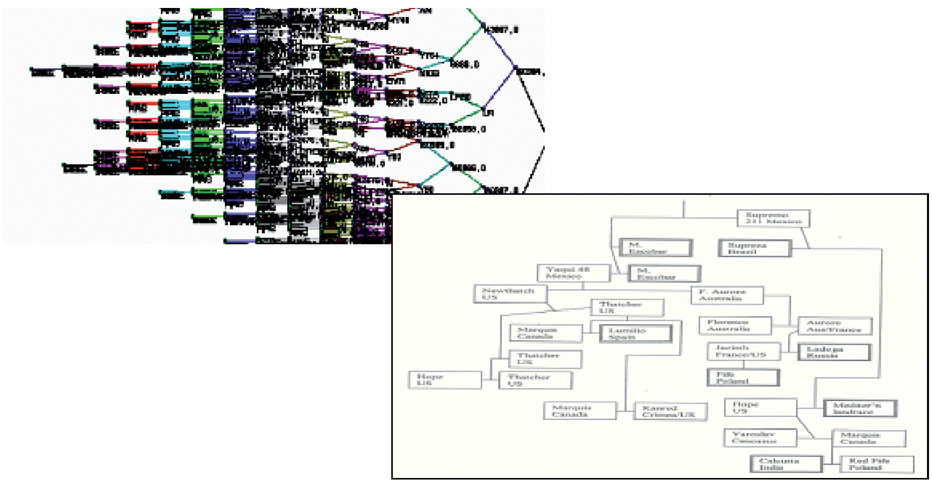
During the third phase, the selected varieties are registered, if relevant intellectual property rights (IPR) are applied for, and seed production will take place to provide the growers with sufficient quality seeds. The latter phase will take another three to five years.

Genetic Resources in the Plant Breeding Process

Genetic resources can be directly used as the basis of the plant breeding process, but they may also be indirectly used.

Direct use implies that the genetic resources are used to recombine genes and develop an end-product, a plant variety. This can be done through crossing and/or other breeding techniques. The history and/or type of the genetic resources that are used for recombination may differ. In most cases the plant breeder will make use of modern plant varieties that consist of good sets of genes. This should result in better varieties with an even better set of characteristics like high yield, disease resistance, high quality, etc. In some cases the desired characteristics cannot be found in modern varieties and then other genetic resources like landraces and wild relatives are used. Material from research projects may also be used. Furthermore, genes from other organisms like microbials and pathogens may be used.

Fig. 2 The pedigree of the Sonalika wheat variety

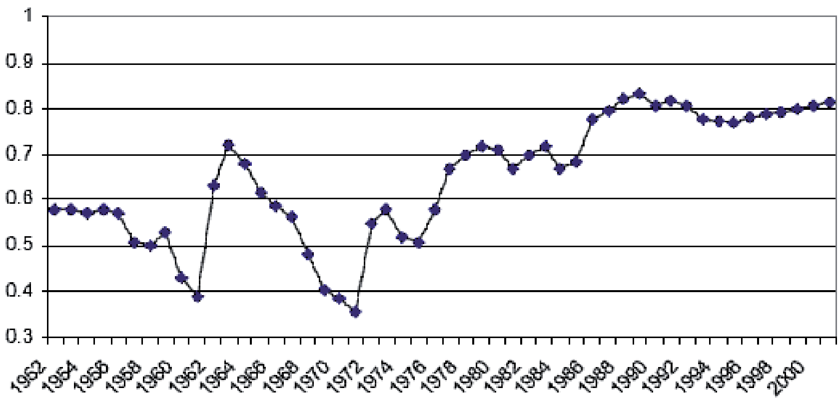


Therefore, plant breeding results in varieties consisting of new gene combinations from genetic resources; both from recombination within the species and recombination between species. Fig. 2 demonstrates in a very clear manner that recombinations are continuously being made to get new varieties. In this example the pedigree, in other words the crossing history, of the Sonalika wheat variety is shown.

Genetic resources are used in the plant-breeding sector to create new plant varieties, which are again genetic resources. Therefore it can be seen that plant breeding can also have a positive impact on biodiversity. Through plant breeding, new variations, new diversity may be created. An example of improvement in diversity is shown in Fig. 3. Lang and Bedo (2004)[1] showed in their study that a pedigree analysis on the Hungarian wheat varieties registered over the last 50 years indicated a high increase in genetic diversity. Breeders have used a wide range of genetic resources to arrive at the new wheat varieties. Moreover, farmers are now using more varieties than in the past.

In an article on genetic erosion and the role of plant breeding, Van der Wouw et al. (2009)[2] identify a phase where the access by breeders to exotic parent materials increases the diversity (at the allelic level). New breeding techniques and access to gene banks allow for the utilization of genes from related species and transformation techniques may introduce genes from a much wider range of genetic resources. Moreover, the increased breeding efficiency provided by the use of molecular markers supports the breeding of varieties for specific uses and regions, creating larger numbers of varieties. A study of 20 independent analyses, mainly in Europe and North America, showed that reduction of biodiversity through modernization of agriculture could be seen in the 1960s when diversity in the crops researched was low. However, diversity rose again from then on until the end of the century. These trends over the last decades demonstrate that plant breeding has a positive influence on biodiversity at the genetic level, i.e. allelic richness and evenness, which is different from the number of varieties that are available to farmers. Van der Wouw et al. (2009) state that further increase will depend on various issues.

Fig. 3 Weighted Diversity in Hungarian Wheat Production (calculated from COP, number of varieties and market share of varieties; range 0 to 1)



Recombination and use of genetic resources are not limited to one plant breeder: plant breeders made, have made, and will make use of each others' genetic resources, as well as of genetic resources from different countries and backgrounds. Plant species have moved from one side to the other side of the world and may have obtained importance in a new region and/or country. Fig. 4 demonstrates the spread of sugar cane. It is believed that Papua New Guinea and the surrounding area was the center of origin for sugar cane. From there it moved to the north of India where a secondary center of origin developed. Then it moved further around the world, with Brazil currently the top producer.

It is not only that plant species move around the world, but also that those species may be used in a different way and therefore gain importance. Sugar cane for example is now also important for

[1] Láng, L., Bedo, Z. 2004. Changes in Genetic Diversity of the Hungarian Wheat Varieties registered over the last Fifty Years. In Genetic Variation for Plant Breeding. Proceedings of the 17th EUCARPIA General Congress, Tulln, Austria, Sept. 8-11, 2004.

[2] Van der Wouw Chris Kik, Theo van Hintum, Rob van Treuren and Bert Visser,. Genetic Erosion in Crops: Concept, Research Results and Challenges, 2009 in press. Centre for Genetic Resources, the Netherlands (CGN) – Wageningen University and Research Center, Wageningen, The Netherlands.

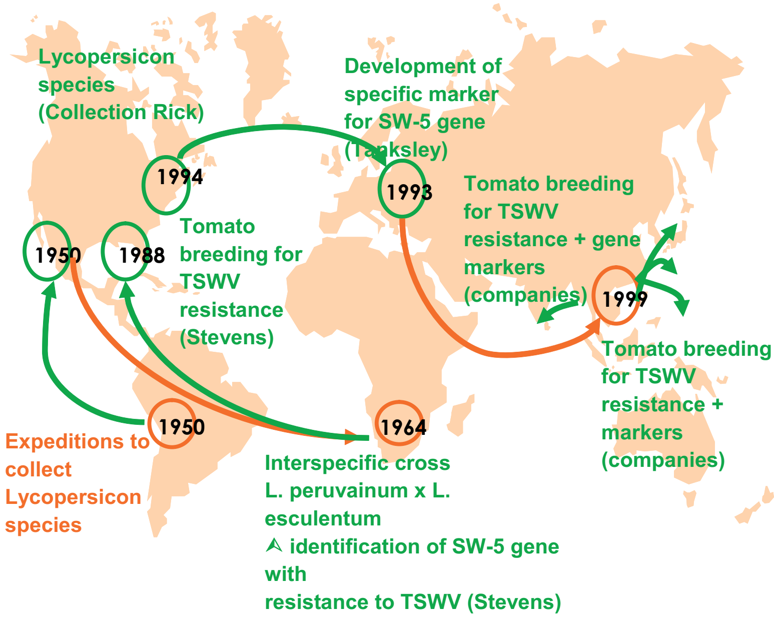
ethanol production. Furthermore, crops may adapt and move to different regions. Maize for example has moved to the north of Europe, while sugar beet has been adapted for tropical conditions.

Fig. 4 Domestication, the Spread of Sugar Cane over the World

The flow of tomato resistance genes for the Tomato Spotted Wilt Virus (TSMV) in Fig. 5 show that interesting genes are also used by different breeders and in different continents.

From the above it can be concluded that no plant breeder, no nation, is completely independent in terms of genetic resources: both developed and developing countries have come to rely on non-indigenous crops for their food and agricultural supply. A study assessing the degree of a country's dependence on non-indigenous crops (measured in terms of calorific contribution to nutrition from crops whose center of diversity is outside the country in question) has shown that all countries grow or import crops from distant lands (Palacios, 1998)[3]. Table 1 shows the dependency levels for a range of countries.

Fig. 5 Flow of TSWV-Resistant Germplasm around the World



From the figures given by Palicios it can be seen that, for example, Ghana is just as dependent on crops originating outside of Ghana (70 to 81 per cent), as Italy is on crops originating outside of Italy (71 to 81 per cent).

[3] Flores Palacios X (1998) Contribution to the Estimation of Countries' Interdependence in the Area of Plant Genetic Resources. FAO, Commission on Genetic Resources for Food and Agriculture.

Table 1 Levels of Dependency on Genetic Resources from Outside the Countries

Country	*Dependency (%)*	*Main source of energy supply*	*Primary region of diversity of crops*
China Japan Republic of Korea	46 - 55 43 - 61 30 - 54	Non-native - wheat, sugar, maize, potato Native - rice and soybean	East Asia - rice, soybean, orange, Brassica, millet, tea, onion
Bangladesh India Nepal	14 - 21 35 - 47 47 - 57	Non-native - wheat, maize Native - rice, sugar cane, millet	South Asia - rice, banana, sugar-cane, sesame, millet, Brassica rapa, B juncea
Kenya South Africa Ethiopia	89 - 98 90 - 98 28 - 56	Non-native - Phaseolus, maize, sweet potato, potato, cassava, banana, plantain, wheat, rice Native (for Ethiopia) - tef, Avena Abyssinian, Brassica carinata	East and Southern Africa - sorghum, millet, yam
Brazil Andean Region Argentina Colombia	81 - 94 89 - 95 84 - 94	Non-native - wheat, sugar, rice, maize, soybean, plantain, banana Native - potato, Phaseolus (for Andean Region); cassava (Brazil)	Andean region – pineapple groundnut, sweet potato, tomato, cocoa, Phaseolus, potato, cassava,
US Canada	77 - 100 84 - 99	Non-local - wheat, sugar, soybean, potato, maize, barley, rice, groundnut	North America - sunflower

Source: Papacios, 1998

Plant genetic resources are also frequently used indirectly in the plant-breeding process. "Indirectly" means that genes are not recombined or transferred and plant genetic resources may be used in test trials. Standard varieties, for example, are used to see if newly developed varieties are better or not. This may be in relation to yield, but can also be related to resistance or any other important characteristic.

Pathogens are other genetic resources that may be used in the breeding process. To measure if plants are resistant to certain diseases it is important for plants to be infected with the pathogen. Hence, the pathogen serves as test material.

Another group of genetic resources that are important in the breeding process are pollinators. Bees, humble bees and flies, are necessary and frequently used in the seed production of various plant species.

Conclusion: Plant breeding equals to a continuous flow of genetic resources from anywhere to everywhere.

Maintenance of Genetic Resources

As genetic resources are very important for the plant-breeding sector, the sector is taking care or assisting in the maintenance of genetic resources. First of all, plant breeders maintain genetic resources in their own collections. These collections consist of breeding materials, modern varieties, landraces and wild relatives. The collections maintained are principally for their own use. However, if necessary, relevant materials may be exchanged or even offered for reintegration in nature.

Second, plant-breeding companies support gene banks and/or botanical gardens. The Dutch breeding companies, for example, account for 10 to15 per cent of the budget of the Dutch gene bank: they do that by multiplying accessions from the gene bank. Furthermore, they assist in the characterization and evaluation of gene bank accessions. In some cases, financial support is provided to gene banks in order to maintain their facilities and their genetic resources. In exchange, plant breeders may make use of the accessions for their breeding activities without further consent.

Lastly, support may be provided for the collection missions of gene banks or other organizations for maintenance and sustainable use of those genetic resources. Lately, the Dutch vegetable seed companies have supported collection missions on spinach and onion/leek of the Dutch gene bank.

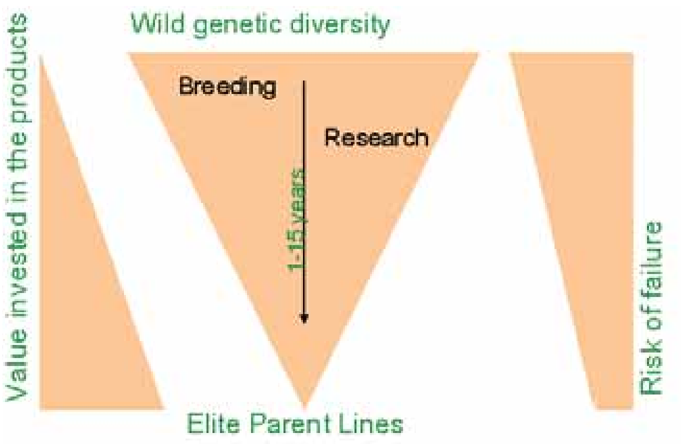
Conclusion: Without maintenance of genetic resources = no availability of genetic resources = no plant breeding

Availability of Genetic Resources

As seen earlier in the text, genetic resources are closely linked to plant breeding. Hence, it is important that they are easily available for plant breeders to do their work. In addition to materials from their own collections, plant breeders obtain traditional genetic resources from gene banks, botanical gardens, farmers, markets and sometimes from the wild. Plant breeders make use of any opportunity for obtaining new materials. Most materials have no value at the stage they are found, but in some cases interesting genes can be discovered in those materials after a lot work of recombination and selection.

Fig. 6 demonstrates schematically what the consequences are of the use of different genetic resources in the breeding process. Looking at the top of the chart we see that wild relatives as such have limited value, as they are distanced from an elite parent line or a variety useful for grower or farmer. The value invested in a wild relative for further improvement is in general still very limited. Where wild relatives are used for plant breeding the number of genetic resources should be high. The chance of failure is still quite important and a lot of work needs to be done to get the right set of characteristics in the variety. During the process a lot of genetic resources will be discarded as they have no practical use.

Fig. 6 Schematic Representation of the Increase of Value of Genetic Resources through Research, the Number of Genetic Resources required and the Risk in using Genetic Resources, ranging from Wild Relatives to Elite Parent Lines



The more we know on plant genetic resources, the less accessions for the breeding process are required. In Fig. 6 this is represented in the central triangle. Moreover, the more we know on the variety the more will have been invested in research: this is shown in the left triangle in Fig. 6. As more is known on genetic resources, these have a greater value for the final variety, the risk of failure in the plant breeding process by using the material will be lower. The latter is demonstrated on the right in Fig. 6.

Thus, it can be seen that availability of genetic resources is important for plant breeders to do their work: a continuous flow is important. Moreover, it is also important not only that wild relatives are available, but also that materials that are further developed, whether research material or even final varieties are available. Plant breeders have recognized this importance while developing an IP system: the plant variety protection system. With this system the product as such can be protected for further multiplication. However, the protected products can be used for further research and breeding without any further consent of the owner and without any cost after commercialization. Therefore, it can be concluded that the so-called breeders' exemption is a benefit in itself.

Conclusion: The Availability of Genetic Resources leads to Benefit Sharing

Conventions on Biodiversity and Plant Genetic Resources

Up to 1992, the plant-breeding process, the exchange of genetic resources, the maintenance of these resources and sharing of benefits arising from their use and exchange, such as breeders' exemption, support in maintenance of genetic resources, capacity building and research projects, worked in harmony as genetic resources were seen as common heritage. After 1992, in particular after December 29, 1993 when the Convention on Biological Diversity (CBD) was ratified, genetic resources were no longer seen as common heritage, but as resources with sovereign rights.

The goals of the CBD are threefold:

- conserving genetic resources;
- sustainable use of genetic resources; and
- organizing Access and Benefit-Sharing (ABS).

The latter, especially, has important implications on the traditional working methods of the plant-breeding sector. A traditional balance of activities as described above has been disrupted as genetic resources can no longer be obtained without prior informed consent and mutually agreed terms.

Fig. 7 Demonstration of Different Products that may or may not be linked to Access and Benefit Sharing

How to organize prior informed consent and how to settle mutually agreed terms is not yet clear. Political debates/negotiations on establishing an international regime on access and benefit-sharing have been taking place for many years. It is planned that a regime should be ready by 2010, but it is unsure whether this will be reached as the expectations of the different countries are very different. Fig. 7 shows all the products that may or may not be linked to benefit-sharing. Some countries are of the opinion that the ABS regime should only deal with genetic resources, while others think it should not only relate to genetic resources, but also to biological resources and their derivatives and products.

For plant genetic resources for food and agriculture a specific arrangement existed before the establishment of the CBD. The International Undertaking on Plant Genetic Resources for Food and Agriculture stimulated the exchange and use of plant genetic resources for food and agriculture. As this was based on common heritage, it needed to be renegotiated. This resulted in the ratification of the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA) on June 21, 2004. The conservation and sustainable use of plant genetic resources are the first two goals of the IT PGRFA. The third objective is related to ABS. In the IT PGRFA a special multilateral system has been developed for a limited number of plant species in order to make the ABS arrangements simple, efficient and equal for all players by using an internationally accepted Standard Material Transfer Agreement (SMTA).

The ratification of the CBD and IT PGRFA has wide implications for the plant-breeding sector. Flows of genetic resources are interrupted and it is no longer automatic that plant breeders can use any resources they like. There are new or different systems for obtaining genetic resources and the existing benefit-sharing mechanism may no longer suffice. Moreover, it should be recognized that new systems are often not in place and it is not clear how ABS should be organized.

Therefore, obtaining plant genetic resources may be more difficult if not impossible; it may result in burdensome administrative procedures and lack of transparency on exchange of genetic resources: the plant-breeding process may slow down. Furthermore, it should be realized that not using genetic resources may result in their loss.

The multilateral system of the IT PGRFA solves some of the problems mentioned above in obtaining access and organizing benefit-sharing. The use of the SMTA is simple, efficient and creates a level playing field. Unfortunately the system is only limited to a number of species, not including some important field crops like soybean, a lot of important vegetable species and all ornamentals.

The multilateral system recognizes the importance of intellectual property.. Moreover, in the SMTA the value of the breeders’ exemption is recognized as a benefit. No obligatory financial benefit-sharing is required when new varieties are freely available for further research and breeding.

Conclusion

Plant breeding and genetic resources cannot be seen separately; they strengthen each other and one cannot exist without the other. In light of the CBD and IT PGRFA it is important with the implementation of the ABS systems in both Conventions that a continuous flow of genetic resources is guaranteed under reasonable conditions. The multilateral system of the IT PGRFA seems to be most consistent with the plant-breeding sector. It would therefore be useful to expand the system to cover the whole breeding sector.

Discussion

DOMINIQUE DESSAUW (CIRAD FRANCE): Just for the sake of clarification: as the breeders' exemption is only valid under the UPOV system, this advantage only applies to the UPOV system. But you have other plant variety protection in the world, like the patents in the US, where you cannot use the protected varieties for further breeding without the agreement of the owner. The breeders' exemption is therefore only available under the UPOV system.

AAD VAN ELSEN (PLANTUM NETHERLANDS): I would like to comment on the last remark from the gentleman from CIRAD. I think that is a very valuable comment and this is why within Plantum we decided that we wanted to change our position with regards to the breeders' rights system and the patent system. We have now adopted the position that any plant material should be freely usable without any consequences for it, and even in the case where you develop new material and innovate on old and protected material, be it varieties or plants protected by plant breeders' rights or by patents, you shouldn't be bothered with licenses anymore. That, at least, is the position we have taken and I hope we will get a lot of support for it. It is precisely touching on the point that we need to get access in the best way possible.

FACILITATING ACCESS AND ENSURING BENEFIT-SHARING GLOBALLY: THE MULTILATERAL SYSTEM OF THE INTERNATIONAL TREATY ON PGRFA

Ms. COSIMA HUFLER*

Introduction

The FAO estimates that over the course of history about 10,000 different crops have been used for food production for humankind and in the last century alone, 75 per cent of these crops have been lost.

Nowadays, only 120 crops feed 90 per cent of the world's population and only four of them provide 60 per cent of their dietary energy. These four key food plants are rice, maize, wheat and potato.

For these, and indeed for many other crops, the following holds true: over centuries, generations of farmers have created countless varieties, often far from a plant's center of origin and irrespective of national boundaries.

As a result of the loss in crops and the dependence on a small number of species, we now live in a world in which no one single country can be considered self-sufficient in terms of being able to survive solely on indigenous crops within its borders. Interdependence and global cooperation will be ever more important with the projected consequences of climate change and potentially new diseases or pests.

It is projected that with a rise in mean global temperature by only 2 per cent, yields in Africa, Asia and Latin America could decline by 20 to 40 per cent. Severely increased risks of drought and flooding all over the world are already being felt.

The International Treaty on Plant Genetic Resources for Food and Agriculture, which entered into force in 2004, gives due recognition to these developments. It is an international agreement with the overall goal of supporting sustainable agriculture and global food security.

The Treaty allows governments, farmers, research institutes and agro-industries to work together by pooling their genetic resources and sharing the benefits from their use – thus protecting and enhancing our food crops while giving fair recognition and benefits to local farmers who have nurtured these crops through the millennia.

The Treaty covers all plant genetic resources for food and agriculture and recognizes, in accordance with the Rio Principles and the Convention on Biological Diversity, the sovereign rights of states over their own plant genetic resources for food and agriculture.

It is in the exercise of those sovereign rights that the Contracting Parties to the Treaty have established a Multilateral System both to facilitate access to plant genetic resources for food and agriculture and to share, in a fair and equitable way, the benefits arising from the utilization of these resources.

* Chair of the Governing Body of the ITPGRFA

What does the Multilateral System mean and where are the Gains in Practice?

On the Access Side

The Treaty's truly innovative solution to access and benefit-sharing is its declaration that 64 of our most important crops will comprise a pool of genetic resources that are accessible to everyone: this is the Multilateral System. On ratifying the Treaty, countries agree to make their genetic diversity and related information about the crops stored in their gene banks available to all.

The Multilateral System is thus an easily accessible global pool of genetic resources that is available to potential users under the terms and conditions of the Standard Material Transfer Agreement.

The 64 crops it comprises represent 80 per cent of the food we derive from plants, encompassing to date more than 600,000 unique varieties. This list of crops covered by the Multilateral System was established according to the criteria of food security and interdependence.

Access to genetic materials within the MLS is through the collections in the world's gene banks. Under the Treaty, collections of local, national and international gene banks will be put in the public domain.

These can include collections of local seeds kept in small refrigeration units of research labs, national seed collections housed in government ministries or research center collections that contain all known varieties of a crop from around the world.

They also include the vast collections of the Consultative Group for International Agricultural Research (CGIAR), a consortium of 15 international research centers.

The Multilateral System therefore provides scientific institutions and private sector plant breeders with the opportunity to work with, and potentially to improve, the wide range of materials stored in gene banks worldwide or even crops growing in fields.

On the Benefit-Sharing Side

Those who access genetic materials through the Multilateral System agree to share any benefits from their use through the established benefit-sharing mechanisms.

These include the sharing of monetary and other benefits arising from commercialization, in accordance with the terms and conditions of the SMTA:

- recipients of genetic resources from the Multilateral System pay an equitable share of commercial benefits whenever a product resulting from those resources is commercialized with restrictions for further research and breeding
- the funds thus acquired will form part of the Treaty's Funding Strategy and will flow primarily to farmers, especially in developing countries and countries with economies in transition, who conserve and use plant genetic resources for food and agriculture.

And the sharing of non-monetary benefits:

- exchange of information, technology transfer and capacity building
- managing and conserving plant genetic resources on farms
- sustainable use of plant genetic resources

The International Treaty on PGRFA, through its Multilateral System, establishes the legal conditions for building and sustaining an effective and efficient system for the utilization of plant genetic resources by plant breeders for sustainable agriculture and food security. Since the resources are treated as a pooled good, there is no requirement for negotiations of individual contracts with individual owners. This means transaction costs are reduced significantly.

Particular importance will be devoted to the information system of the MLS and its key role as the core of the International Treaty.

The Role of Information in the Implementation of the Multilateral System

The Multilateral System is clearly a major success in that a number of its constituent elements have been or are being put in place, in particular the Standard Material Transfer Agreement. This also shows that over 100,000 accessions are being exchanged annually through the Standard Material Transfer Agreement.

The great bulk of this exchange is represented by the collections of the International Agricultural Research Centers of the Consultative Group on International Agricultural Research and other international institutions, and of established gene banks in developed countries. Therefore the system requires measures for further strengthening and promotion of an even wider application.

For a plant breeder seeking useful materials, the Multilateral System is only as good as the information systems that describe these materials. Providing such information is a "distributed" function, not managed from the center, but the task of gene bank and information system managers throughout the world.

Identification and documentation of material within the Multilateral System has so far been partial. It is vital for the long-term effectiveness of the system that Contracting Parties now take the necessary steps to document their relevant plant genetic resources and to facilitate access to them. There is a need to support the relevant authorities and entities, particularly in developing countries, in improving the information base.

Tackling these matters as a priority will support Contracting Parties in overcoming their difficulties in making their relevant plant genetic resources for food and agriculture available through the Multilateral System and the Standard Material Transfer Agreement.

During the past biennium, the Secretary has worked with the Contracting Parties and other users of the Multilateral System, to promote the exchange of experience and the documentation of best practices, help improve understanding of the Multilateral System and the Standard Material Transfer Agreement and resolve problems that were identified.

It is therefore proposed that, during the forthcoming biennium, this work be continued as a priority through a variety of proposed measures aimed in particular at strengthening national capacity to implement the Multilateral System, and by providing further guidance in the implementation of the SMTA.

Conclusion

Plant breeders worldwide pursue their profession in search of ever-increased quality of crops. Is it to increase the yield, to tolerance of environmental pressures, resistance to viruses, fungi and bacteria or to increase tolerance to pests and herbicides.

The challenges of our time, in particular global warming and the ever-growing population numbers will make plant breeding ever more important to humankind.

Seed exchange, from which all eventually benefit, has been the reality of agriculture since its beginning. Our enormous and growing world population will only be fed if we continue to draw freely on the widest possible range of resources at all times.

The IT PGRFA established the system in response to the current challenges and will increase the world's adaptability to these challenges. The Multilateral System of the IT PGRFA provides gains to plant breeding both through access to currently 600,000 unique varieties - and these numbers are ever growing – as well as through benefit-sharing, notably the information provided through the system. And in all fairness, access in itself is already a major benefit.

Discussion

ORLANDO DE PONTI (ISF): We have seen two excellent presentations, but I notice one important difference: Ms. Hufler, can you explain to me why on your slides on non-monetary benefits you did not mention the important benefit of unrestricted access for further breeding?

COSIMA HUFLER (ITPGRFA): I think this is mainly in the way of how I conceptualized the presentation. Since there are different perceptions of access and benefit-sharing in the world, you as a plant breeder would see that free access to genetic diversity and to the crops is already a benefit in itself. However, in a developing world where countries struggle to actually have the means to be able to nurture and conserve their local genetic varieties, it is important that they obtain the funds to actually undertake these measures. This is the other aspect of benefit-sharing, and therefore I think it is a question of conceptualizing. Yet I agree that it is also a fact that free access, as is stated in my conclusion, is a benefit for all.

BERNARD LE BUANEC (ORGANIZING COMMITTEE): Do you think that there is any chance that the list of crops in Annex I will be expanded one day? There are still some important crops for food and agriculture that are not on that list. What should we do about that?

COSIMA HUFLER (ITPGRFA): If I could foresee the future – this is a very difficult question to respond to because of course it is for political discussion. I think for merely pragmatic reasons, once the system is fully up and running and is being used widely, then there might be the tendency that people would want to extend it.

EXCHANGING MATERIAL IN THE DAILY BUSINESS: THE OPERATIONS OF THE MULTILATERAL SYSTEM AND THE STANDARD MATERIAL TRANSFER AGREEMENT (SMTA)

Dr. SHAKEEL BHATTI*

Introduction

The Multilateral System (MLS) of the International Treaty on Plant Genetic Resources for Food and Agriculture (the Treaty) is the first multilaterally managed global public good of the 21st century – a global gene pool of more than 1.1 million samples of plant genetic material governed collectively and multilaterally by its 121 Contracting Parties (CPs). Through this gene pool the CPs control – and are responsible for – the basis of more than 80 per cent of the world's food from plants, and are our most important tool for adapting to climate change in agriculture in years to come.

Over the biennium 2008-09 this MLS has been operationalized and become functional. In less than two years, the Treaty has gone from a legal text to a practical reality for agriculture worldwide. The Consultative Group on International Agricultural Research (CGIAR) carried out more than 440,000 transfers of genetic material per year using the SMTA of the Treaty.

The Multilateral System

At its First Session in 2006, the Governing Body of the Treaty (GB) decided that the focus in the implementation of the Treaty should be "to make the MLS functional". In order to so, the GB adopted the SMTA - a bilateral contract that facilitates and regulates exchanges of genetic material under the MLS between providers and recipients.

The SMTA contains provisions on monetary and non-monetary benefit-sharing, and provides - in case of dispute - for a Third Party Beneficiary (TPB) that represents the interest of the MLS. However, a number of legal, technical and administrative uncertainties still remain, and developing countries in particular have requested assistance in factoring the SMTA. At its Third Session in June 2009, the GB therefore took the necessary decisions and gave adequate guidance to the Secretary and the CPs to overcome these uncertainties over the next biennium 2010 - 2011.

In order to have a clear and accurate picture of what is actually available "in" the MLS it is important that countries take legal and administrative steps to identify their materials that are part of the MLS; and that these be adequately documented, so that they can be used by plant breeders, farmers, researchers and other stakeholders.

At its Third Session the GB in Resolution 4/2009 therefore requested all CPs to report on their plant genetic resources for food and agriculture (PGRFA) that are in the MLS and to take measures to make information on these resources available to potential users. It also encouraged CPs to provide information on the collections of legal persons not part of the government, whom they regard as forming part of their national plant genetic resource systems. Several CPs, as well as the first private sector bodies, have already informed the Secretariat of the Treaty of the materials which are included in the MLS. Furthermore, efficient coordination and integration of existing information systems on agricultural plant genetic resources are being developed in a wide partnership with the CGIAR Centers, the Global Crop Diversity Trust, and national and regional gene banks.

* Secretary of the ITPGRFA

However, the MLS and the implementation of the SMTA are not self-executing: CPs must engage with the system, manage the system and provide minimum support to users in order to overcome initial uncertainties and hesitancies. Priorities for the moment are to resolve such uncertainties that are preventing some providers, including some CPs, from effectively incorporating their materials into the MLS; and to document and make visible the materials that are in the MLS, which is the conditio sine qua non in order for the Treaty to successfully address the challenges the world currently faces: climate change, population growth and persistent poverty.

In order to regulate the day-to-day management of the Treaty's systems and interaction with stakeholder communities, the GB requested – in Resolution 4/2009 – all CPs to establish policy, legal and administrative measures to provide facilitated access to PGRFA through the use of the SMTA. It urged developed country CPs to provide appropriate assistance to developing countries for capacity-building, awareness-raising, promoting the exchange of information among those responsible for implementing the SMTA at the national level and electronic management of the SMTA and related reporting.

The Benefit-Sharing Fund

Under its Funding Strategy the Treaty establishes a Benefit-Sharing Fund with the aim of supporting conservation projects, especially in developing country CPs. This fund is fed by voluntary and mandatory payments by governments, the private sector, and other organizations.

There have been two quantum leaps which the Treaty has achieved under the Funding Strategy since the Second Session of its GB:

First, in accordance with the mandate the CPs gave it, the Bureau of the GB in 2009 approved the first 11 small-scale projects to be funded by the Benefit-Sharing Fund. These grants amount to a total cost of more than half a million US dollars. By successfully completing this first test-run of benefit-sharing under the Treaty, it has proved that international benefit-sharing within a binding legal architecture on a multilateral basis does work.

The second advancement offers a concrete and practical perspective on how to address the needs that were expressed by many agricultural stakeholders worldwide within a few weeks of the call for project proposals: a Strategic Plan for the Benefit-Sharing Fund of the Funding Strategy has been adopted which sets a fund-raising objective of 116 million US dollars and a working target of 50 milion US dollars from 2009 to 2014.

Discussion

MAGNI BJARNASON (VIBHA SEEDS): What about plant species that are not on the Annex I list of the 64 crops but might fall under the CBD? I am thinking of crops like Jatropha. What does a person have to do if he wants to go to a country in order to collect accessions and take them to some other place? What processes are required, if any, in this case?

SHAKEEL BHATTI (ITPGRFA): In fact the question of non-Annex I material falls into two particular aspects: The first one is that non-Annex I material, that has been brought under the Treaty in the form of so-called Article 15 agreements between the institution holding those materials and the Governing Body, is governed by a second MTA which has also been adopted by the Governing Body and is essentially identical with the SMTA, except for one footnote. The second aspect is that for non-Annex I material that is not under such agreements and resides in Contracting Parties, the decision is entirely up to the Contracting Parties. There is nothing to prevent Contracting Parties from transferring such material using the SMTA. At the same time the Treaty does not provide or require transfers under the SMTA, and indeed some Contracting Parties have included non-Annex I material by a purely voluntary decision.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): So the answer is, if material is not brought under the Multilateral System, then the CBD rules, which are based on national sovereignty and national jurisdiction, are applied.

ZEWDIE BISHAW (ICARDA): From your presentation one can see that most of the material included in the Multilateral System comes from the CG centers, which are also the major holders of the gene pool, and that some countries are to some extent reluctant in providing germplasm. Do you see any trend in other countries joining and bringing their collection under the Treaty, as well as in terms of the exchange of the materials?

SHAKEEL BHATTI (ITPGRFA): The reason why I was mostly quoting data and figures from the CGIAR is because from the CG we have the most systematic and complete data set on SMTA operations and on transfers of material. As you saw in the videos on the information tools that have been developed, we are currently working on obtaining comprehensive and reliable data on SMTA use and exchange under SMTAs at national and regional levels, but this is quite a major exercise. So that being the case, as a caveat, it is indeed right that in the first biennium a number of countries were still in the early stages and considering how to apply and implement the Treaty domestically. I think that in the third session of the Governing Body a number of concerns were really discussed and there has been quite an increasing trend of inclusion of material. We have seen that both developing countries, e.g. Brazil, Namibia and Zambia, and developed countries such as the Netherlands, Germany and all the members of the Nordic gene bank, have notified inclusion of material and in some cases also material that goes beyond Annex I. So there is, I think, a clearly identifiable trend towards an increasing momentum in inclusion of material.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): Just to add some figures to this answer, in addition to the over 600.000 accessions in the CG-system, from Europe alone 250.000 accessions have already been added to the Multilateral System.

WORKING WITH THE MULTILATERAL SYSTEM: EXPERIENCES OF A SEED COMPANY – REPRESENTATIVES FROM PRIVATE SECTOR

Drs. J.J.M. LAMBALK*

Within Enza Zaden, a vegetable breeding company located in Enkhuizen, Netherlands, we have active breeding programs in 20 vegetable crops. Actually only five of these crops are listed in Annex 1 of the International Treaty, which means that the majority of our crops are not included in the MLS. In practice, however, many gene banks in Europe already implement and use a SMTA for MLS but also for non-MLS vegetable crops.

Certain gene banks do not supply genetic resources of non-MLS vegetable crops anymore without SMTA. This is a very important change. Availability of genetic resources was, prior to this development, based upon good personal relations with gene bank staff members and counteracts (i.e. multiplication and description) executed by the breeding companies: highly appreciated and necessary counteracts in order to help/facilitate a gene bank organization. Will this situation change because of the implementation of the MLS/SMTA?

I refer to the paper of Anke van den Hurk/Plantum.NL: "Access and use of genetic resources is of vital importance for continuity in vegetable variety development and improvement" Therefore the MLS and its SMTA should function as a tool to facilitate access to genetic resources rather than to complicate it. We recognize, as important advantages of the MLS/SMTA, standard conditions and terms for access and benefit-sharing which will provide legal certainty for both provider and user.

But to formalize access of genetic resources according to the MLS for users (i.e. breeding companies) without (financial) support from the (inter)national authorities to the suppliers (i.e. gene banks) is not consistent. The entire MLS/SMTA will only function effectively in case of well-organized gene banks worldwide.

Frequently, in our contacts with gene banks, Enza Zaden is confronted with deviations from the current MLS/SMTA arrangements, lack of proper organization of the gene bank, poor description of the collection and seed quality problems (either germination and/or contamination).

It is necessary to involve the private sector more in order to improve the MLS/SMTA/ABS set-up and its practical implementation.

*	Director Enza Zaden R&D B.V., The Netherlands

DISCUSSION

CHRISTOPH HERRLINGER (BDP GERMANY): I have only a very brief remark regarding the issue of benefit-sharing. You mentioned, I think it was on slide number 10, that you do not agree with the idea of benefit-sharing in the case of the breeders' exemption. I think one should very clearly state that this relates to the monetary benefit-sharing because if we talk about the breeders' exemption, the breeders' exemption as such is already a very important form of benefit-sharing in the sense that the material is made available again. I think that all the breeders who use PVP, and with that the plant breeders' exemption, also engage in other forms of benefit-sharing, for example capacity-building. Do you agree?

JOEP LAMBALK (DIRECTOR ENZA ZADEN R&D B.V.): I agree. The point is that in our discussions within Plantum, especially when you are talking about IPR, be it a patent or plant breeders' rights which is in fact also a form of IPR, what we are really fighting for is that, in the case of plant breeders' rights the material is freely available for everybody, so that there are no specific conditions with respect to the benefit-sharing aspect.

FRANÇOIS BURGAUD (GNIS FRANCE): You said that once you were supposed to pay 50.000 Euros for one accession. I would like to know if it was an accession inside or outside the multilateral system of the International Treaty, and more generally I would like to know if you have encountered the same problem that we have now with field crop gene banks and also with vegetable gene banks. Because of lack of funding, you are saying, more and more gene banks use the concept of "material under development" to ask for payment for their material. In rice, for example, IRRI is more often asking for money for granting access to their material. So I would like to know if you have noticed the same negative evolution in vegetable gene banks.

JOEP LAMBALK (DIRECTOR ENZA ZADEN R&D B.V.): Just to give you an answer to the first question; that was in tomato, so in fact outside. The reason that the gene bank was asking 50.000 Euros had to do with some specific research on that material for which they wanted to be compensated as well. But I think that is often the case. You will probably agree that often material is not completely blank, it always comes with a specific description, and well, the gene bank would like to see benefits for all of it. But it makes things rather complex when we have to compensate for things that the gene banks have done but in fact we did not ask them to do.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): Just by way of a short interruption: I think the beauty of the Multilateral System it that is does not only provide you with material, it also provides you freely with information on the material, which is very important to stress.

ILDEFONSO JIMENEZ (IRRI): Just a comment on the previous comment: as far as I know we only charge shipping costs for accessing material from our gene bank.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): I think your statement is correct, but now you are stating that you only ask shipping costs, if any costs, for material from the gene bank. Yet I think reference was made to material coming from your breeding programs, and I'm not sure whether you could also enlighten us as to the policy of IRRI on breeding material that is under development.

ILDEFONSO JIMENEZ (IRRI): I am not as familiar with the breeding materials in this respect, but I am not aware of any costs other than the shipping costs for the gene bank material.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): I think it is important to make that distinction between breeding materials and gene bank materials. The latter should be freely available - and if not you've got a good case for complaint, especially here at FAO at the International Treaty when it comes to Annex I materials.

ORLANDO DE PONTI (ISF): That was exactly the case: the difference between a basic germplasm from the gene bank and material under development. As far as I have been informed there is a monetary payment if it is material under development, at least in the case of IRRI.

ISABELLE CLÉMENT-NISSOUS (GNIS): To make the link between genetic resources and the presentation this morning on rice and gene markers: is it possible in the near future to have finger printing with genetic resources? When we follow ABS negotiations we see lots of presentations claiming that very soon we will have gene reporting for all the world's biodiversity. My question is: is it possible to do exactly the same for all accessions that we know in breeding material, accessions contained in gene banks and the like?

The question has been referred by the Chair of the session to the final discussion.

IMPLEMENTING THE INTERNATIONAL TREATY AT THE NATIONAL LEVEL: WHAT IS THE IMPACT ON THE SEED SECTOR?

Ms YLVA TILANDER*

The Swedish National Program for Biodiversity in Agriculture, Public Awareness

The launch of strong national programs is one of the priorities in the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. National programs are the foundation of regional and global efforts in this area and provide a framework in which the International Treaty can be implemented.

The Swedish national program is called the Programme for Diversity of Cultivated Plants (POM). It was decided by the Government in the year 2000 after a proposal from the Board of Agriculture.

The goals of the POM (2010 to 2015) are as follows:

- Conservation and use of plant genetic resources shall contribute to improved food security, sustainable agriculture and maintain biodiversity in Sweden.
- The program shall help our biological cultural heritage come alive.
- Materials that are conserved within the program shall be well documented, and information about the materials shall be available for free.
- The program shall promote international cooperation in the areas of conservation, utilization, access to plant genetic resources and benefit-sharing of the profits arising from their use.

The program has five fields of activity involving different tasks and actors. These fields of activity are conservation, utilization, research and development, training and information, as well as international efforts.

One of the activities in the program up to now has been specific "calls" to the public to report their seeds and material, with the aim of recovering information about forgotten and less-known species. Calls have been issued in eight areas, examples being vegetables and fruits and berries.

This has been a very successful activity and has largely contributed to raising public awareness and interest. Also, it has led to a great deal of new information about varieties that were previously less known – for example peas, where a lot of genetic variability was detected with the help of the public.

The Nordic Regional Approach in the Nordic Genetic Resources Center

The five Nordic countries Denmark, Finland, Iceland, Norway and Sweden – being rather small and to a large extent sharing the same plant genetic material – have for 30 years found it natural, practical and economical to collaborate on one common gene bank. The Nordic Gene Bank was established as an institution under the Nordic Council of Ministers in 1979.

In January 1, 2008, the mandate of this institution was extended to cover Nordic forest genetic resources and Nordic farm animal genetic resources: the Nordic Genetic Resources Center (NordGen) was established. Since January 1, 2009, environmental aspects related to the management of genetic resources have also been integrated in the NordGen mandate.

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The NordGen vision is:

"NordGen secures a biological basis for life for the present and for the future"

The four priorities in the strategy 2008 to 2012 are:

- Conservation
- Sustainable use
- Information and networking
- International activities

Twenty-eight thousand accessions are stored in NordGen. The plant material consists of cereals (60 per cent), vegetables (18 per cent), forage crops (16 per cent), root crops, oil plants and pulses (5 per cent) and industrial/medicinal plants (1 per cent).

The Svalbard Seed Vault

The Nordic Gene Bank has been storing a Nordic safety collection in an abandoned coal mine in the permafrost at Svalbard/Spitzbergen for more than 25 years. The experiences gained have been one of the points of departure for the Svalbard International Seed Vault, opened in February 2008.

The Vault provides the most secure storage possible and is available for "black box" storage, according to international agreements. NordGen manages day-to-day operations under an international steering committee.

For what Purposes are the Seeds from the Gene Bank used?

As mentioned, sustainable use is an important priority for NordGen and where we would like to increase emphasis in the years to come.

NordGen has always emphasized the importance of making the material and related information available. The documentation information system SESTO, developed at NordGen, is key in this.

The categories of receivers of material have varied quite a bit over the years. Research use and private persons (or "other" uses) dominate. Use by breeding companies constitutes a smaller share, but it would not surprise me if this share were to increase in the near future, given new needs in response to climate change.

Ongoing efforts to encourage use of the gene bank include discussions on pre-breeding and new collaborations with various stakeholder groups like seed-saver organizations and partners in ornamental plant genetic resources. A new field regarding the cultural history of crop plants has also recently been initiated.

Practical Experience in using the SMTA

The Standard Material Transfer Agreement has been used by NordGen for all transfers since October 1, 2007. Since then 96 SMTAs have been issued covering 2,523 accessions. The material concerned is mostly beans and cereals.

NordGen has decided to use the SMTA (with footnote) regarding both Annex 1 and non-Annex 1 species. Small samples of seed for home use are delivered with a "Hobby MTA".

Experience from the National Seed Industry

The SMTA has only been in use for a short period of time. This is why there are at present only a few records on its use by the national seed industry in Sweden. The breeding companies in Sweden have up to now to a large extent had the required resources in their own gene banks. However, there seems to be a particular interest in disease-resistant genes – related to climate change – and from that perspective there may be a growing interest in using gene bank material in the coming years.

The Nordic countries are small, as are their markets for the plant breeding industry. At the same time climate change contains a particular challenge for our part of the world. Accessions adapted to warmer and rainier summers could be found in other regions. However, normally these are not adapted to the very specific light regime we have in the Nordic countries, with many hours of daylight during summer. Further, it is foreseen that there will be an increased need for disease-resistance genes in the new climate.

Therefore, there is an ongoing discussion on how to meet these challenges. Within the framework of the Nordic Council of Ministers an analysis is presently being elaborated. The analysis includes NordGen, the plant breeding industry, research, other stakeholders as well as polic-makers. Pre-breeding has been identified as a main area where concerted action would be welcome. A public/private partnership is being proposed.

Other proposals are:

- revitalization of Nordic research education on this subject;
- initiatives for collaboration between the Nordic entities engaged in breeding of fruits and berries with the aim of dividing responsibility;
- joint evaluation and testing of vegetable varieties for the Nordic market in order to clarify the adaptation of available varieties to the different climate zones in the Nordic countries;
- a common approach to the testing required in order to receive protection from European plant breeders' rights.

The Nordic Ministers of Agriculture were briefed at a recent Nordic Council of Ministers meeting, but no decisions have yet been taken.

However, it is already possible to reflect on the factors permitting such an open discussion between potential competitors. NordGen has been proposed to administer the new initiative, if decided. My belief is that it has been made possible to formulate such a proposal, as, for decades, the Nordic countries have collaborated in these matters and that has built up a large degree of trust.

Swedish International Support regarding Plant Genetic Resources, including the International Treaty

The Nordic countries have had a very positive experience in collaborating on a regional basis regarding plant genetic resources. In evaluations this approach has repeatedly scored high in efficiency and cost-effectiveness. It has therefore been natural for NordGen and Sweden to encourage this approach in other regions around the world.

Over the years this has resulted in the building-up of several regional networks, receiving considerable support.

Sweden has, in various ways, supported the conceptual development of the International Treaty, both in the negotiations leading up to the decision taken in Madrid 2006 and in the implementation phase.

The International Treaty and its implementation is not easy to grasp. Capacity-building has therefore been a focus for supporting efforts, identified by many Contracting Parties. When Sweden in 2008 decided to make a major contribution to the implementation of the International Treaty it was therefore logical to focus on this area. The Secretary of the International Treaty, in collaboration with Bioversity and FAO, proposed a three-party collaboration in this area, and the Swedish International Development Cooperation Agency, Sida, decided to fund it with 1 million US dollars over two years (spring 2008 to spring 2010).

The FAO/Bioversity capacity-building project focuses on the practical implementation of the Multilateral System of Access and Benefit-Sharing.

The project objective is to develop improved national laws and regulations as well as administrative and information technology arrangements for the operation of the Multilateral System. The project also aims to improve knowledge among national stakeholders of issues underlying the implementation of the Treaty and in particular the Multilateral System.

Concerning activities that have already been or are being implemented, let me present them in two sections.

Regional
The project envisages a series of regional workshops to discuss regional coordination for the implementation of the Multilateral System of Access and Benefit-Sharing (MLS) as well as to pave the way for national assistance. At present, the joint program has almost completed its regional phase and, through its workshops, developed partnerships with recognized regional organizations. To date, the following workshops have been held:

Place	*Date*	*Partnering organization*
Lusaka, Zambia	September 2008	SPGRC
Entebbe, Uganda	March 2009	EAPGREN
Cairo, Egypt	April 2009	AOAD
Kuala Lumpur, Malaysia	May 2009	RECSEA-PGR

Another regional workshop is scheduled to take place in Nadi, Fiji on September 23 and 24 in partnership with the Secretariat of the Pacific Community (SPC).

The regional workshops produced a number of concrete recommendations which the joint program is following up. Examples of such concrete results at the regional level are proposed guidelines including elements of a model law from the Cairo workshop and a regional road map for implementation of the MLS from the Entebbe workshop.

National
Based on proposals for assistance that have been positively appraised by the project steering committee, countries which are receiving direct assistance under the joint program are Kenya, Morocco, Sudan, Zambia, Ecuador, Peru, Malaysia and the Philippines.

Based on available resources, assistance is also being considered for two other interested countries (i.e. Madagascar and Guatemala). Other countries have expressed interest in receiving assistance but the current budget does not allow for meeting these requests at present.

Activities vary based on national needs and priorities. In general, they consist of national capacity-building workshops and studies to review and assess the national legal and administrative frameworks of relevance to the implementation of the MLS. Recommendations for their upgrading are covered, including the description of possible legislative and administrative measures and their main elements or draft primary legislation, executive orders and administrative guidelines for consideration by national authorities.

Conclusion

- The Swedish national program has stimulated great public interest in biodiversity in agriculture as well as collecting material not documented before,
- The SMTA is now in use in the Nordic region, after some need for clarification regarding non-Annex 1 crops (SMTA with footnote is now used for them as well),
- The Nordic regional approach has proven cost effective and has built trust,
- Interest and positive experiences for regional approaches can be found worldwide,
- Climate change poses new challenges, resulting in the need for collaboration. The International Treaty for Plant Genetic Resources for Food and Agriculture provides a good framework in this respect,
- Capacity-building is needed in implementing the International Treaty.

Discussion

TASI (FAO): How are Sweden or the Nordic countries in general thinking of handling the benefit-sharing issue?

YLVA TILANDER (MINISTRY OF AGRICULTURE, SWEDEN): We fully accept and endorse the Multilateral System on Access and Benefit-Sharing of the International Treaty. We agree in principle that a company that has developed material and gets benefit from it will have to send a certain percentage to the Benefit-Sharing Fund. As has been mentioned, there have been separate donations, for instance from Norway, to the Benefit-Sharing Fund, but at this point I am not aware of any more plans in this direction.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): Let me just reiterate in support of what you just said that all Nordic countries, including Sweden, have also accepted the use of the SMTA for non-Annex I crops, as well as Germany and the Netherlands, and many other European countries are preparing to take a similar position.

General Discussion

FRANÇOIS BURGAUD (GNIS): What Bert Visser said in his introduction holds true because in this kind of discussion the seed industry of developing countries from Asia or Africa is not involved. Yet if you ask a breeder in Africa or in Asia if access is important to them they will say "yes", and in a way access is more important for the new seed industries in developing countries than for the old seed industries in Europe.

The second point: I think we may all agree on is the fact that the Multilateral System needs more money, and I think that even the seed industry has to think concretely about the possibility of making voluntary contributions to the Multilateral System. This, however, should not be a pretext for governments not to put any money in the Multilateral System. I think it's important that at the policy forum the day after tomorrow, we as the global seed organizations say to governments: "you have to invest money in genetic resources and in the Multilateral System". We can say that it is of great importance for breeding, and breeding is too important for food security to accept that governments don't invest in it.
Last but not least, we have to pay attention to the fact that the insistence on on-farm management of genetic resources is also often a pretext for governments not to do anything other than that. We all know that you need more than on-farm management today to increase world genetic progress.

LEO MELCHERS (SYNGENTA SEEDS): I would like to respond to a comment from the audience by Plantum with respect to IP protection in plant breeding. I would like to stress the fact that breeders' rights and patent rights are actually different but complementary systems, as well as the fact that both these systems are important to foster innovation in agricultural research. Mr. Niebur, too, made a comment about the importance of both systems this morning. We do not support the Plantum IP position that plant breeders' rights are sufficient in that respect and that patent rights can be ignored or denied. It is really critical to have balanced co-existence of both plant variety protection and a patent rights system in order to stimulate innovation in plant breeding and to address the increasing challenges we are confronted with in agriculture.

ISMAHANE ELOUAFI (CANADIAN FOOD INSPECTION AGENCY): Where do intellectual property or breeders' rights reside for those 600.000 varieties that you have in your MLS?

SHAKEEL BHATTI (ITPGRFA): In fact, perhaps a very general factual description of what the Treaty provides in respect of IPR under Part IV on the Multilateral System: the Treaty provides in its Article 12 that the material in the form received from the Multilateral System, including its genetic parts and components, should not be the subject of IP claims that would restrict further access in the terms of the Multilateral System. There is a second set of provisions under Article 13, that is the benefit-sharing part, which provides that - though there is no explicit reference to IPRs - under commercial benefit-sharing the payment of 1.1 per cent of sales from products incorporating material from the Multilateral System is triggered when that product is not available without restrictions for further breeding, research and training. Those are, very generally speaking, the two main provisions in the Treaty that refer to IPRs, explicitly or implicitly.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): So the Treaty and the MLS accept the reality and in fact IPRs, and a distinction is made between the two major types of IPRs that we have in the sense that voluntary payments are expected, or are hoped for, in the case of plant breeders' rights, whereas mandatory payments are due in the case of patent rights that lead to successful commercialization.

ORLANDO DE PONTI (ISF): The issue of perception has already been mentioned. On the one hand there are people, quite often breeders, who are interested in access, and on the other side there are other people that are interested in benefit-sharing. And my experience over many years is that they are more interested in financial benefit-sharing, in money. So I have a question to the speakers, I make a comparison with what happened in Norway: let's say that I can convince the Government of the Netherlands to do the same, and that they bring to the Funding Strategy 0.1 per cent of the seed sales in my country. Does it mean that as a breeder in my country I am exempted from Article 13 and that I am not obliged to pay the 1.1 per cent, if I ever get into that situation where access is no longer unrestricted?

COSIMA HUFLER (ITPGRFA): No, it does not exempt you, obviously, but you could probably argue with your Government who would make that commitment of 0.1 per cent of the value of seed, that they would probably also take over your charges when it comes to commercialization.

ORLANDO DE PONTI (ISF): If the whole world followed this approach, and if Marcel Bruins is right that the world's turnover of seeds is 36 billion US dollars, it would bring your Funding Strategy 36 million US dollars. That is a nice amount of money, and maybe the administrative load for the industry could be abandoned.

BERT VISSER (WAGENINGEN UNIVERSITY, NETHERLANDS): Further to this discussion, the Secretary of the International Treaty has just reminded me of a resolution that was agreed upon at the last Governing Body of the International Treaty, which foresees that the countries that are members of the Treaty are supposed to develop innovative approaches towards the funding of the implementation of the Treaty. "Innovative approaches" of course is a very general description, but it is certainly also a reference to the one case that we have in practice, which is the Norwegian example of 0.1 per cent of the seed sales being shared with the Treaty for its implementation. But, of course, the Treaty and all those who are trying to implement it are open to any other innovative approaches, including, undoubtedly, voluntary contributions from the private sector.

[Session Summary by B. Visser]

First of all the interdependence of countries, as well as of breeding companies upon each other was mentioned.

It was also mentioned how important access to plant genetic resources is for the future; not only the future for plant breeding, but as an immediate consequence for the future of food security in our world, and I think this shows how important a proper access and benefit-sharing regime is.

The International Treaty is a unique, legally binding instrument that provides a sectorial solution to conservation and also to the utilization of plant genetic resources, and with that access to plant genetic resources.

The core of that International Treaty is the Multilateral System which provides a very transparent ABS regime for the 64 crops in Annex I that come under the Multilateral System. The Multilateral System is operationalized by a Standard Material Transfer Agreement that is increasingly being used; of course it takes some time for such a new instrument to come into use. It's not only used for material that is part of the Multilateral System, but it is also used for many other transfers, and I mentioned the case of Europe where not only a few countries but in fact the entire European network of gene banks has agreed that it will use the SMTA not only for Annex I crops but for all exchanges.

It is important to stress the need to involve the private sector in the implementation of access and benefit-sharing measures, and I think that goes without any further saying.

It is important to stress here also that the material that has been incorporated in the Multilateral System is a source of genetic resources, traits and characteristic of interest to the sector.

Let me summarize by saying that the success of the International Treaty will depend on implementation at the international level and also at regional and national levels, as well as at the level of institutions and companies.

I mentioned already that the Multilateral System is a system of access and benefit-sharing; it tries to realize access, but it can only do so if benefit-sharing is also realized. The Funding Strategy of the International Treaty is the major mechanism to achieve this.

Let me close by saying that we have also seen some contributions on the issue of IPRs this morning and this afternoon, and I am trying to make a link to the access and benefit-sharing agenda: I think we all need more discussion on this issue in order to further clarify how efficient ABS and IP regimes should be and how they should and may impact on the sector.

Session 2. Conclusion, presented by the Chairperson
The importance of plant genetic resources for plant breeding; access and benefit sharing

- Plant breeding and the sustainable use and conservation of genetic resources are interdependent.
- The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is a unique and innovative legally binding instrument providing facilitated access to genetic material for plant breeding at the international level
- The Multilateral System (MLS) of the ITPGRFA provides a consistent Access and Benefit-sharing option for plant breeding activities
- The Standard Material Transfer Agreement (SMTA) of the ITPGRFA is a contract between the provider and the recipient that is simple to use and facilitates access to germplasm
- The involvement of the private sector in the design of Access and Benefit-sharing schemes is necessary for a well functioning Access and Benefit-sharing mechanism
- Material in the MLS is a source of genetic traits and characteristics of interest
- The full success of the ITPGRFA and its MLS will depend on local, national and regional implementation, as well as on the availability of funds at the local, national and regional level.