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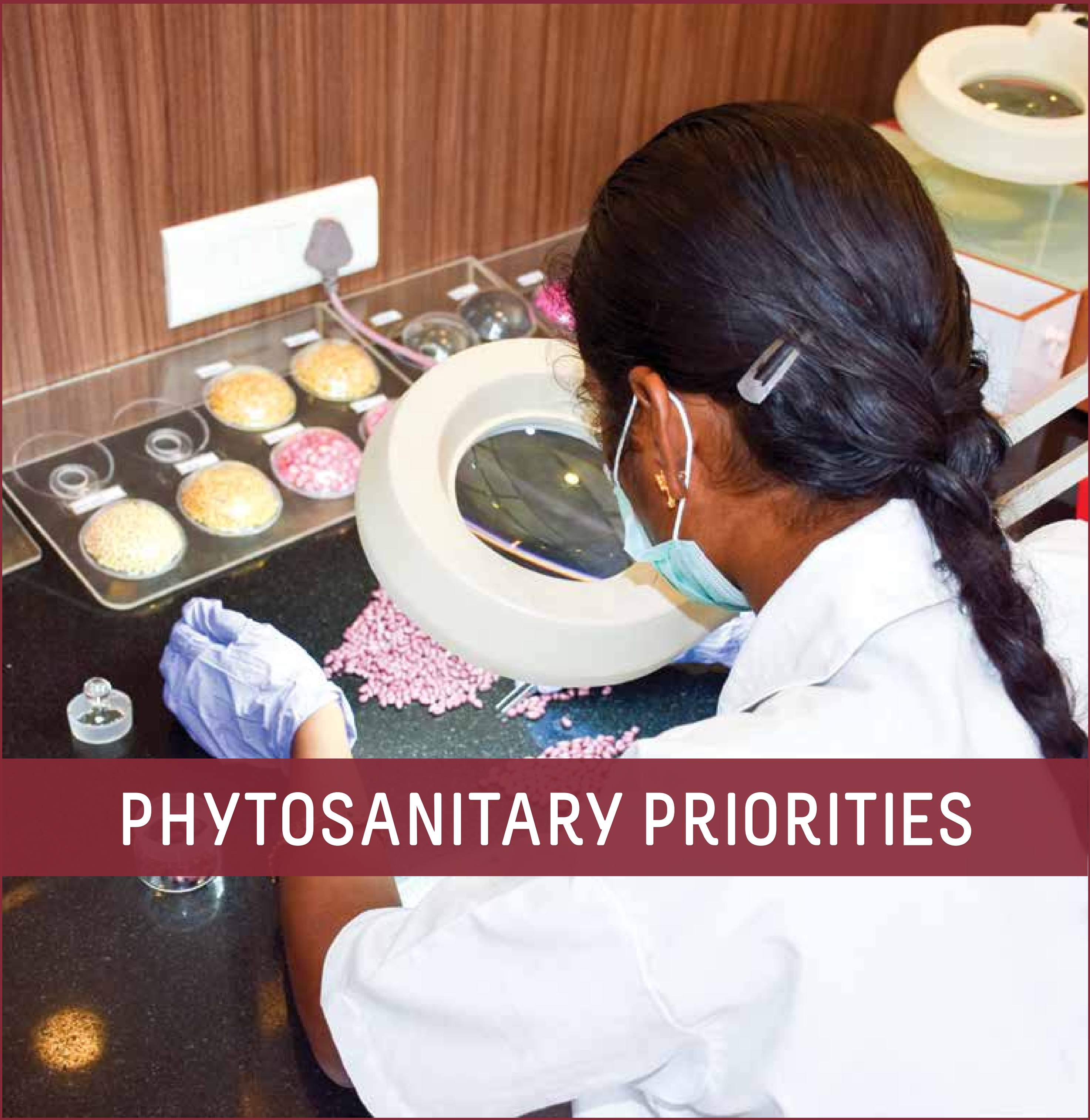

PHYTOSANITARY PRIORITIES

All About Plant Breeding Innovation

APSA members who have participated in any of our recent technical sessions, or have been keeping abreast of the latest advances in seed breeding, at some point will have certainly heard mention of CRISPR-Cas, a cutting-edge gene-editing tool and one of the many latest breeding techniques in what is collectively being referred to as 'plant breeding innovation'. But what is it really that seed scientists, policy makers and legislators are talking about? For more clarity on the matter, *Asian Seed* reached out to Michael Keller, ISF Secretary-General.

Concisely, what is plant breeding innovation? What technologies, mechanisms and tools does it include, and what does it not include?

Plant breeding innovation reflects the continuum of innovation in plant breeding. It does not focus on a particular group of methods, nor is it defined by them. The way we see it, the concept of plant breeding innovation is not a new one – the continuous development of new varieties in all crops is in our DNA! I mean, which other industry invests up to 25% of its turnover in innovation? In the infographic we developed (pp. 20-21), we wanted to convey the message that the latest methods of plant breeding innovation represent an accumulation of knowledge and an evolution of methods – not a revolution.

In answer to the question, plant breeding innovation includes the whole range of tools that plant breeders use. Perhaps the most significant milestone in recent years has been the advances in genome editing. Under this umbrella, you have targeted mutagenesis which results in minor changes at a precise location in the DNA (e.g., ODM and SDN 1 and 2, which can be done with technologies such as ZincFinger, TALEN, and CRISPR-Cas). These methods have given us waxy corn, non-browning mushrooms and powdery mildew-resistant wheat. You also have cisgenesis which involves the transfer of genes within the gene pool. Applications include the scab-resistant apple and the Phytophthora-resistant potato.

Many APSA members, especially breeders, have the impression that many of these newer technologies/ innovations (such as CRISPR Cas9) are inaccessible and only financially-secure MNCs/ organisations can afford to implement them in their programmes. Do you agree?

As I mentioned, consistency is central to our approach – and this applies to the terminology we advise our members around the world to use so that we are truly speaking with one voice. As we are speaking about a much broader concept with regards to innovations in plant breeding, we use 'latest methods', as it is impossible to draw a line between newer and older methods in our continuum of plant breeding. For example, would you say that a method used since 2002 is new or old? The answer is subjective.

One of the biggest concerns plant breeders have is whether they'll be able to use the latest breeding methods, as social stigma and burdensome regulatory barriers could limit their use.

Indeed, the latest breeding methods themselves are financially accessible and we see tremendous opportunities for the whole seed industry, and for all crops. However, it is critical that regulatory burdens do not impede investment. If the burdens and the costs that they generate are too high, investment will be limited to high-value crops, and minor crops will not be in focus. In a world where we have to address global challenges such as climate change and population growth, and even consumer preferences, this will handicap our capacity to innovate.

Further to the examples you mentioned, can you provide any more recent examples of beneficial/successful applications of plant breeding innovation?

There is a real buzz around CRISPR-Cas9. The number of scientific publications speaking about "CRISPR" went from 36 in 2010 to 1,431 in 2016. And the number of articles in international newspapers about "CRISPR" went from 76 in 2010 to 3,553 in 2016 – that's ten articles per day!

Even if these articles cover much broader domains, gene editing technologies are already having an impact on the seed industry as they offer up new possibilities to unlock the untapped potential of biodiversity. However we have to keep in mind that by using CRISPR-Cas, plant breeders are combining their collective knowledge gained over the past 20-30 years – it's not just the use of one method. For example, by knocking out the expression of a single gene, breeders can increase lycopene levels by 25 per cent, which would be in line with what consumers are looking for, like those deep red tomatoes with high lycopene. It also means shortening the breeding cycle compared to traditional plant breeding.

Some recent examples of improved varieties also using newer breeding methods are broccoli with increased antioxidants, easy to prepare salad, carrots with increased beta carotene, or more convenient snackable fruits and vegetables like seedless watermelon, baby cucumbers or grape tomatoes. Or for rice, with increased disease resistance or more efficient nitrogen use via the TALEN method.

What are the biggest opportunities and challenges you see with some of the specific plant breeding innovation technologies/tools mentioned above?

The industry's understanding of plants and their genomes is increasing each year, and it is this knowledge that has boosted our capacity for genome editing in recent years. Now is a great time to be in agriculture as we have a better understanding of genetics and plant biology, enabling us to develop improved plant varieties in response to global challenges such as climate change. For example, characteristics such as pest or disease resistance, as well as drought or flood tolerance. Of course, we will continue to use traditional methods, but the latest methods will help us better predict how the variety can be improved.

This increased capacity for greater precision and faster development – all with the plant's own DNA – makes genome editing methods like CRISP Cas9 very attractive for many in the public and private research field. We also see opportunities for all type of crops and even minor crops.

Finally, I would like to emphasise that we are speaking a lot about the potential benefits for future generations of crops. It's important to be realistic and responsible, and to avoid overpromising.

As for challenges, let's be crystal clear. [Wide adoption of] Plant breeding innovation will only become a reality if the regulatory framework within which we operate at national levels, and also in Asia-Pacific, is a workable one and does not hamper the use of these methods.

ISF's concept paper outlines consistent criteria that regulatory agencies and governments can utilise in determining the scope of regulatory oversight for products developed using plant breeding innovation tools. The paper recognised that the approach taken by governments to translate these criteria into regulatory policy would undoubtedly vary based on respective existing laws and regulation. However, the end goal is one that will ensure proper regulatory oversight while promoting facilitative approaches to how plant varieties are regulated. The underlying principle is that if the same product endpoint is reached through the latest methods as with traditional plant breeding, then they should be regulated in the same way.

ISF engaged with several of our national seed trade association members and with APSA to support their discussions and outreach with public breeders and other stakeholders in the value chain, as well as with governments, to participate in the organisation of roundtables and workshops.

Let's engage together to support plant breeding innovation and make improved varieties accessible in the Asia-Pacific region within a consistent regulatory framework. We must do everything we can to move toward more consistent policies for products developed through the latest plant breeding methods if we are to make them accessible and ensure uninterrupted trade.

One thing we have to remind ourselves of is that each one of us has to speak up to speak out and tell the wonderful story of plant breeding. If we speak as one, we can amplify our voice. Besides the regulatory framework, we also have to work towards consumer acceptance.

ISF recently published a 'Plant Breeding Innovation Discussion Guide', which is available to ISF Members through worldseed.org

MILESTONES IN PLANT BREEDING

CROP DOMESTICATION

Farmers select the best wild species to develop crops

10,000 BC

Domestication of wheat

HYBRID BREEDING

Crossing two genetically different individuals to develop better performing hybrids

1926

More vigorous hybrid corn

MUTAGENESIS

Developing new genetic diversity by exposing crop plants to chemical agents or radiation

1940

Blast-resistant rice

1953

Understanding the structure of DNA

James Watson and Francis Crick identify the double helix of DNA

PLANT BREEDING BASED ON GENETIC INFORMATION

Development of improved varieties by working directly with the DNA

FACTS

For **10,000** years, farmers and breeders have been developing and improving crops

For **150** years, plant scientists and breeders have improved plant breeding on a scientific basis

Today, farmers feed at least **10** times more people using the same amount of land as 100 years ago

By 2050, we will need **50%** more food to feed a population of 11 billion

PLANT BREEDING BASED ON CROSS BREEDING

Development of improved varieties by combining good characteristics from two parents

1865

Mendel's laws

Gregor Mendel describes the inheritance of traits from one generation to the next. His laws become the core of classical genetics

1994

GMO

Introducing foreign genes into the DNA of a plant

Insect-resistant cotton

2000

MARKER-ASSISTED SELECTION

Locating desirable traits in a plant for efficient selection and breeding

Barley resistant to yellow dwarf virus

now

TARGETED BREEDING

Using modern tools such as genome editing for more targeted breeding

Waxy corn

future

ISF International Seed Federation
Seed is Life