Pakistan Biotechnology Information Center (PABIC)

ARISEN

April to June 2020

ISAAA International Service for the Acquisition of Agri-biotech Applications

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Pakistan Biotechnology Information Center

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National News

High-Yield Garlic Variety Developed in Pakistan

A new garlic variety developed at the National Agricultural Research Centre (Narc) has yielded 24 tonnes per hectare — the highest ever produced in the country as compared to other garlic cultivars grown locally.

Developed variety called Narc-G1 has been recorded approximately 185.43 grams as compared to the local 'Lehson Gulab' which is only 35.45 grams. Narc-G1 is relatively larger than other garlic varieties while cultivation in a suitable climate and proper care can enhance its productivity.

The new variety was approved by the Pakistan Agriculture Research Council (Parc) and it was also vetted last month by the seed councils of Punjab and Khyber Pakhtunkhwa. According to Parc chairman Dr. Mohammad Azeem Khan, the new variety will not only increase the earnings of the farmers but also reduce the bill of garlic imports.

https://www.dawn.com/news/1567493/high-yield-garlic-variety-developed

International News

Five Countries Produce More than 90% of Biotech Crops Worldwide

High adoption of biotech crops continued in 2018 with 26 countries planting 191.7 million hectares worldwide. This area is an increase of 1.9 million hectares or 1% from the previous year's area. The average adoption rate in the top five biotech crop-growing countries increased to reach close to saturation, with the United States at 93.3% (average for soybeans, maize, and canola), Brazil at 93%, Argentina at close to 100%, Canada at 92.5%, and India at 95%.

The top five biotech crop-growing countries planted a total of 174.5 million hectares of biotech crops, equivalent to more than 90% of the total global area. The United States has led other countries in commercial cultivation of biotech crops since 1996 and produced 75 million hectares in 2018. Brazil, the second largest and the top developing country producer of biotech crops planted 51.3 million hectares. Argentina maintained its ranking as the third-largest producer of biotech crops in the world and planted 23.9 million hectares. Canada, the fourth-largest producer of biotech crops in 2018, planted 12.75 million hectares, and in India, six million farmers planted 11.6 million hectares of Bt cotton.

Agri Biotech News

Bt Brinjal Farmers Earned 21.7% More, Satisfied with Yield and Crop Quality

A new study conducted by Cornell University reveals that eggplant farmers in Bangladesh have attained significantly higher yields and revenues by growing the insect resistant, genetically engineered (GE) Bt brinjal (eggplant). According to the study published in Frontiers in Bioengineering and Biotechnology, the four Bt brinjal varieties yielded, on average, 19.6% more eggplant than non-Bt varieties and earned growers 21.7% higher revenue.

The study, led by Dr. Anthony Shelton, professor of entomology and former director for the Feed the Future South Asia Eggplant Improvement Partnership, is the first to document the economic benefits of four Bt brinjal varieties though the Bangladeshi market chain and their acceptability to farmers and consumers.

The survey was conducted in the five most important brinjal producing districts in Bangladesh – Rangpur, Bogra, Rajshahi, Jessore, and Tangail – through face-to-face interviews with 195 Bt farmers and 196 non-Bt farmers.

Of Bt brinjal farmers, 83.1% were satisfied with their yields and 80.6% were satisfied with the quality of their crops. However, only 58.7% of non-Bt brinjal farmers were pleased with their yields and 28% said that a large portion of their fruit was infested with eggplant fruit and shoot borer (EFSB) larvae, which is not a concern with Bt brinjal because of its inherent resistance to EFSB. Because of higher yields, increased revenue, and better fruit quality, about three-quarters of Bt brinjal farmers said they planned to grow the crop again next season.

Rice Genetically Engineered to Resist Extreme Heat also Produces Up to 20% More Grain

As plants are exposed to light, the protein complex photosystem II (PSII) energizes electrons to help power photosynthesis. But heat or intense light can damage a key subunit, known as D1, and stop PSII's work until the plant makes and inserts a new D1 into the complex. Chloroplasts have their own DNA, including a gene for D1, and most biologists assumed the protein had to be made there.

A research team led by plant molecular biologist Fang-Qing Guo of the Chinese Academy of Sciences believe that D1 made by a nuclear gene could work just as well—and be made more efficiently, as its synthesis in the cytoplasm instead of the chloroplast would be protected from the corrosive by-products of photosynthetic reactions. Guo's team tested the idea in Arabidopsis, and took its chloroplast gene for D1, coupled it to a stretch of DNA that turns on during heat stress, and moved it to the nucleus.

The team found that the modified Arabidopsis seedlings could survive extreme heat in the lab—8.5 hours at 41°C—that killed most of the control plants. The same Arabidopsis gene also protected tobacco and rice. The more remarkable discovery was found at what happened at normal temperatures. Engineered plants of all three species had more photosynthesis. Tobacco's rate increased by 48% and grew more than the control plants. In the field, transgenic rice yielded up to 20% more grain. The modified Arabidopsis had 80% more biomass than controls.

"It truly surprised us," Guo says. "I felt that we have caught a big fish."

Gene Editing of Three BnITPK Genes in Oilseed Rape Reduces Phytic Acid in Seeds

University of Kiel researchers and partners used CRISPR-Cas9 to edit three genes in oilseed rape to reduce phytic acid in seeds. The results are published in Plant Biotechnology journal.

Phytic acid is a main source of phosphorus in plants but is considered as anti-nutritive for mono-gastric animals including humans because of its adverse effects on essential mineral absorption. Furthermore, undigested phytic acid causes algal bloom on bodies of water, harming aquatic life. To reduce phytic acid in oilseed rape, the researchers knocked out three functional gene copies of BnITPK, which are involved in the production of phytic acid in plants. Through CRISPR-Cas9 mutagenesis, low phytic acid mutants were obtained which also had significant increase of free phosphorus.

Based on the results, the techniques used could be adopted in rapeseed breeding to increase protein value with no adverse effects on oil contents.

Knockout of the OsNAC006 TF Causes Drought and Heat Sensitivity in Rice

Researchers from Nankai University, China, and partners revealed that transcription factor (TF) OsNAC006 is consistently expressed in rice, and knocking it out using CRISPR-Cas9 results in drought and heat sensitivity. The findings are published in the International Journal of Molecular Sciences.

Rice responds to different abiotic stresses during growth. Plant-specific NAM, ATAF1/2, and CUC2 (NAC) transcription factors play vital roles in regulating several important growth and developmental processes. To date, 170 NAC transcription factors have been identified in rice, but their functions are still unknown. Nankai University researchers found out that the transcription factor OsNAC006 is consistently expressed in rice, and regulated by H2O2, cold, heat, abscisic acid, indole-3-acetic acid, gibberellin, NaCl, and polyethylene glycol 6000 treatments. Knocking out OsNAC006 using CRISPR-Cas9 led to drought and heat sensitivity. Further analysis showed that OsNAC006 regulates the expression of genes mainly involved in response to stimuli, oxidoreductase activity, cofactor binding, and membrane-related pathways.

The results show the vital role of OsNAC006 in drought responses and provide valuable information for improving stress tolerance through genetic engineering.

BIOTECH NEWS

Sugar from GM Sugarcane at Par With That from Conventional Sugarcane

CTC used three of their developed varieties of insect-protected sugarcane designed to control sugarcane borer damage to compare it with the conventional sugarcanes. These were grown in four different plots to produce four batches each of processed raw sugar, for a total of 12 independent batches. The researchers then used event-specific probes and DNA detection methods to identify the junction of sugarcane genomic DNA as well as the inserted DNA of two of their GM varieties. The same approach was used for the third GM variety. The experiments were validated using ELISA assays. The study showed that no event-specific DNA and no GM proteins were detectable in all 12 batches of raw sugar from the GM sugarcanes, concluding that there are no distinguishable differences between the sugar produced from the GM lines versus the sugar from their non-GM counterparts.

New Protocol: Genome Editing Using Rice Zygotes

Researchers from Tokyo Metropolitan University presented a new protocol for CRISPR-Cas9- based genome editing using rice zygotes. This addresses some technical hurdles faced in the application of gene-editing technology. The description of the technique is published in Current Protocols.

Genome-editing technology for targeted mutagenesis of plants using programmable nucleases has been extensively used for next-generation plant breeding. Just like any new technology, there are some technical challenges in the application, such as low rate of macromolecule delivery into plant cells and tissues or difficulties in plant transformation and regeneration. Thus, Erika Roda and Takashi Okamoto developed a new protocol using rice zygotes. The genome-editing system is developed via polyethylene glycol/calcium- mediated transfection with CRISPR-Cas9 components in rice zygotes, which are produced by in vitro fertilization of isolated rice gametes. The plasmid DNA harboring a CRISPR-Cas9 expression cassette or preassembled Cas9 protein–guide RNA ribonucleoproteins are transfected into zygotes, leading to the regeneration of plants with a high frequency of the targeted mutation.

This new protocol has the potential to improve the molecular breeding methods of rice and other crops.

Study Puts End to Intense Scientific Debate on Peanut's Origin

In 2019, researchers from The University of Western Australia, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and Fujian Agriculture and Forestry University sequenced the peanut's complex genome. At the same time, researchers from the International Peanut Genome Initiative also made the breakthrough in sequencing the peanut genome. Soon after the two results were published in the same issue of Nature Genetics, an intense scientific debate arose due to a difference in findings and opinion regarding the timeline of when the peanut first originated.

The cultivated peanut originated from the hybridization of two wild ancestors, giving it a very complex tetraploid genome, according to Professor Rajeev Varshney, ICRISAT's Research Program Director and Adjunct Professor at The UWA Institute of Agriculture. Professor Varshney said their results suggested the hybridization event occurred around 450,000 years ago. However, the other group suggested the origin to be less than 10,000 years.

Professor Varshney's team compared the approaches made by the two groups and analyzed the cause of the underestimation in the other group's timeline. They found that the other group had overlooked the major role of insertions and deletions, or InDels, in the DNA sequence. "If you do not consider the InDels, this will underestimate the divergence timeline," Professor Varshney said. He also said he hoped these critical analyses will rest the scientific debate over the origin timeline of the cultivated peanut.

Zambia to Release 2 Drought Tolerant Cowpea Varieties

Zambia will soon welcome two new varieties of drought tolerant cowpeas that can produce up to 10 percent more yield than their parent varieties despite the heat, drought, pests, and diseases that are prevalent in the country. The two new crops can potentially increase food security and lead to higher farmers' income.

The development of Lunkhwakwa and Lukusuzi cowpea varieties is a collaborative project led by the Food and Agricultural Organization of the United Nations (FAO), International Atomic Energy Agency (IAEA), and the University of Zambia. Seeds of local Zambian cowpeas were exposed to gamma irradiation in the FAO/IAEA laboratory in Austria, then were brought back to Zambia. These were subjected to field tests and were observed to mature earlier and require less water. Comparing them with conventional cowpeas, the two new varieties were able to withstand drought better while producing higher yield, and perform better against certain pests and diseases. The selection of varieties was conducted with farmers alongside the scientists who helped develop them. Seed production is ongoing and the seeds will be ready for distribution in November 2020.

The project initially aimed to help farmers living in the dry areas of Zambia who cannot produce enough food due to the increased drought brought by the effects of climate change. But since the new varieties were also found to be tolerant to diseases, the developers also plan to grow them in high rainfall areas where yield loss due to cowpea diseases is the main problem.

Review Shows Biotechnological Strategies to Develop Drought Resistant Crops

As a consequence of global warming, the incidence of drought in various regions of the world has been increasing. According to the Food and Agriculture Organization of the United Nations (FAO), in developing countries, drought alone causes more yield loss in crop fields than all pathogens combined, putting food security at risk. In a paper published in Science magazine, researchers from the Centre for Research in Agricultural Genomics (CRAG) present different biotechnological strategies to achieve drought resistant crops, which could be used to mitigate the devastating effects of climate change on agricultural production.

The CRAG researchers explain that plants use different mechanisms to prevent water loss in ensuring their survival when water is scarce. These natural strategies include changes in the growth and architecture of the roots, closing of the stomata, and acceleration of the reproductive phase.

The team also reviewed different strategies that the scientific community has used to increase plant drought resistance by modifying signaling through the plant hormones abscisic acid (ABA), auxins, and brassinosteroids. One promising approach was discovered by the group led by Ana I. Caño-Delgado in 2018, where they showed that by modifying brassinosteroid hormone signaling in Arabidopsis thaliana through the receptor, BRL3 it was possible to obtain plants more resistant to drought without affecting their growth.

International Team Completes Study on Cotton Genomics to Improve Cotton Varieties

A study successfully investigated the genomic similarities between wild and domesticated cotton and found new information that can help develop varieties with improved resistance to conditions caused by climate change.

An international team of experts conducted genetic sequencing and comparison of five cotton species, which included two commercial cotton varieties and three wild cotton species. Their efforts aim to provide the advancement in genomic sequencing for both the commercial and wild species to benefit cotton growers who need to adapt to environmental changes.

The team focused on the genome evolution and diversification of all five allopolyploid (AP) cotton species. They specifically looked into polyploidy, or the heritable condition of having more than two complete sets of chromosomes of an organism. They believe that the common occurrence of polyploidy may suggest its advantage and potential for selection and adaptation and cotton is a powerful model in revealing genomic insights into polyploidy. Results showed that the genomic differences in the five AP cotton species they worked on are fairly subtle. This means that the genetic sequencing of the three wild cotton species, which do not produce the long white seed fibers, is important to understand the ways to improve resistance in commercial cotton species.

This genome sequence information can help other researchers to improve commercial cotton lines with resistance to bacterial, viral and fungal diseases. But more importantly, it can also lead to future studies of cotton lines that will withstand climate change.

The institutions involved in the study are the HudsonAlpha Institute for Biotechnology, the University of Texas at Austin, the U.S. Department of Agriculture's Agricultural Research Service, Nanjing Agricultural University in China, the Chinese Zheijiang A&F University, Alcorn State University, Clemson University, Texas A&M University, and Iowa State University.

Gene Editing Could Yield Herbicide Tolerant, Non-GM Soybeans

Researchers at the Ohio Agricultural Research and Development Center led by Prof. Feng Qu are investigating soybean genetics and using CRISPR-Cas9 technology to genetically engineer herbicide tolerant soybeans.

According to Qu, most of the herbicide tolerance traits in soybeans are based on genes identified from bacteria. However, there are several genes in soybeans that can be modified through precise engineering to enhance herbicide tolerance. When these genes are identified, CRISPR-Cas9 can be used to edit the DNA sequence at a specific location, changing the underlying gene into a herbicide tolerance gene. Since there is no introduced foreign gene, the modified soybean is not regulated as a GMO.

At present, Qu's team have successfully modified the ALS gene and have reproduced plants in the greenhouse to begin seed production. They are currently working on two more genes to be modified to achieve tolerance expression.

International Research Team Discovers Gene to Develop Fusarium Head Blight Resistant Wheat

Researchers from the U.S. Department of Agriculture Agricultural Research Service (USDA ARS) and colleagues from Shandong Agricultural University in China have discovered a gene that can be used in the development of wheat varieties with more resistance to Fusarium Head Blight (FHB), a disease that is a major threat to wheat crops worldwide. FHB shrivels grain and can significantly decrease harvests of wheat and barley. Worse, the toxins released by the fungus Fusarium graminearum, a growing problem in the breadbaskets of Europe, North America, and China, remain in grain intended for food.

The researchers published their discovery and the cloning of the gene, known as Fhb7 in the journal Science. Fhb7 was found in Thinopyrum wheatgrass, a wild relative of wheat previously used to develop varieties of wheat with beneficial traits, such as rust resistance and drought tolerance. The research team found that the gene effectively reduces FHB by detoxifying the mycotoxins secreted by the pathogen. The gene also confers resistance to crown rot, a wheat disease caused by a related pathogen.

They cloned the gene and introduced it into seven wheat cultivars with different genetic profiles to study its effects on plants grown under field conditions. The results showed that the gene not only conferred resistance to scab in the new plants, but it also had no negative effects on yield or other significant traits.

HEALTH BIOTECH NEWS

Plant Viruses Found to Potentially Treat Diabetes, Arthritis

An Italian research team investigated the design and synthesis of plant virus nanoparticles with peptides associated with diabetes and rheumatoid arthritis. Their goal is to re-engineer nanoparticles and unravel therapeutic benefits for both autoimmune diseases.

The scientific team is led by the University of Verona with the help of the John Innes Centre who developed constructs of the cowpea mosaic virus to target diabetes. Peptides were also inserted into the peptide sequence of the tomato bushy stunt virus to obtain the chimeric particles and use it against rheumatoid arthritis. Plant viruses are known to have self-assembling nanostructures with versatile and genetically programmable shells. Their virus nanoparticles (VNPs) can be programmed to incorporate sequences for specific functions.

The scientists were able to observe that VNPs have the potential to modulate immune system response. Using animal models to test the responses, they found out that the peptide-related mechanism in which the VNPs act as both scaffold and adjuvant have an overlapping mechanism of action, therefore supporting the idea that recombinant nanoparticles can prevent diabetes and improve arthritis. This is an opportunity for further research on plant viruses being used for the clinical treatment of human autoimmune diseases.

The full paper is published in Science Advances with reports from John Innes Centre.

CRISPR-Cas9 Used to Transform Normal Maize to Waxy Version

Scientists from Chinese Academy of Agricultural Sciences and Anhui Agricultural University conducted a study to convert a normal maize hybrid into a waxy version using CRISPR-Cas9 mutation. Their findings are reported in The Crop Journal.

Waxy maize is a specialty maize that makes amylopectin starch which has special food or industry values. To ensure breeding efficiency from normal to waxy maize, CRISPR-Cas9 system was used involving desired-target mutation of the Wx locus in the ZC01 background (ZC01-DTMwx). The researchers applied triple selection to segregants to come up with high genome background recovery with transgene-free wx mutations. A total of 6 mutants were obtained among progeny crossed with ZC01-DTMwx. The mutant lines exhibited higher amylopectin contents in the endosperm starch compared to the wild type controls, while the agronomic performance remained similar.

The results of the study show a practical example of CRISPR-Cas9 mutation applied to industrial hybrids for transformation of recalcitrant species.

Researchers in Spain Use Biotech to Produce SARS-CoV-2 Vaccine in Plants

Researchers María Coca and Juan José López-Moya from the Spanish Research Council (CSIC) at the Centre for Research in Agricultural Genomics (CRAG) are using their expertise in plant biotechnology and virology to produce SARS-CoV-2 antigens to be used in vaccine development. The researchers will experiment with different expression systems from plants and have formed a team including an immunologist expert in coronavirus.

In 2019, María Coca has successfully engineered a plant virus to produce antifungal proteins inside plant leaves. This same strategy could be now used to produce SARS-CoV-2 antigens, not only in Nicotiana benthamiana, but also in lettuce plants. According to María Coca, antigen production in lettuce could make it possible to test for oral immunization.

"The production systems we propose would overcome some of the problems associated with other vaccine production systems, such as the difficulties to escalate production, or the need to isolate the antigen and to purify it. Plant systems are also free of other human pathogens, and, the production would be safe at a much lower cost in terms of time and money," explains María Coca.

Plants can be grown easily in developing countries that lack sophisticated protein production methods, therefore contributing large-scale solutions to this global crisis. CRAG researchers have also conducted the adaptation of plant-derived technologies to other platforms that can be adapted for the production of SARS-CoV-2 antigens, such as fast-growing yeast cultures where they have successfully produced antifungal compounds. With these approaches, SARS-CoV-2 antigens could be produced in a matter of days at industrial scales.

CRISPR-Cas9 Technology Reveals Function of OsRhoGDI2

Henan Normal University scientists used CRISPR-Cas9 to identify the function of OsRhoGDI2 in rice plants. The results are published in the Chinese Journal of Biotechnology.

OsRhoGDI2 was isolated as a putative partner of Rho protein family member from rice panicles by yeast two-hybrid, but its role is still unclear. Thus, Kaijie Wang and the team developed OsRhoGDI2 knockout mutants using CRISPR-Cas9 technology. Sequence analysis of the mutants showed base substitution or base deletion which occurred close to the editing targets of the gene in knockout rice. Analysis of the physical characteristics showed that OsRhpGD12 knockout rice plants had lower plant height than the control plants. This was further confirmed by statistical analysis, which indicated that the significant reduction in plant height was evident in the second internodes. These findings suggest that the OsRhoGDI2 gene is linked with the regulation of rice plant height.

OTHER THAN CROP BIOTECH

Omega-3 Canola Oil to Help Reduce Overfishing

Omega-3 oils from canola plants are ready to become available in the global aquaculture market. The omega-3 oils, developed by Nuseed, are considered as the first land-based sources of omega-3 oil, which is normally derived from fish such as salmon or trout.

Salmon get their oil from smaller, fatty fish in the food chain including anchovies and herrings, which, in turn, derive oil from algae. "There is only so much we can fish out of the ocean," Nuseed group executive Brent Zacharias said. Thus, Nuseed, in collaboration with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Grains Research and Development Corporation (GRDC) in Australia transferred the genetic mechanism from sea algae to canola seed.

The research on using canola as omega-3 oil biofactory paid off, with Nuseed finally completing the processing of the first commercial omega-3 oil from 14,000 hectares of canola in the US to be available soon for aquaculture feed and in human nutrition.

Iranian GM Rice Found to Contribute to Environmental Health

A team led by scientists in Iran found that genetically modified (GM) rice helped reduce negative environmental impacts and energy usage as compared to its conventional counterparts.

Researchers from the Agricultural Biotechnology Research Institute of Iran (ABRII) investigated how GM rice differed from its non-GM counterpart in terms of environmental emissions emanating from the application of chemical inputs. Using four GM lines and their non-GM parents as conventional cultivars, life cycle analysis was done using the average of separate analyses of low- and medium-lying cultivars in three isolated regions in northern Iran. There were no differences between the impact categories and indices in the three regions.

The analyses of GM cultivars exhibited less energy utilization, greenhouse gases' emission, and global warming potential as a result of decreased pesticide application. Heavy metals emitted in the air and soil by the GM cultivars were also observed to be less than those of its non-GM parents. By comparing GM rice with its non-GM counterparts, the scientists were able to determine that levels of environmental emissions are directly related to field management practices, particularly the application of inputs and the methods used.

CRISPR-Cas12b/C2c1 Tested in Targeted Mutagenesis of a Dicot

Cas12b/C2c1 has been identified as class 2 endonuclease that can be used for targeted genome editing in rice and mammals. To elucidate its potential applications in dicots, CRISPR-Cas12b system was tested in Arabidopsis thaliana.

Researchers from Hebei University of Science and Technology in China selected BvCas12b and BhCas12b v4 for analysis. Both endonucleases were successfully applied to cause mutations, conduct multiplex genome editing, and create large deletions at multiple loci. There were no significant mutations detected at potential off-target locations. The team also reported the results of their analysis of the insertion/deletion frequencies and patterns of mutants generated using targeted gene mutagenesis which showed the potential use of CRISPR-Cas12b systems for genome editing in Arabidopsis.

Experts Identify Genome Editing and Other Innovations to Accelerate Food System Transition

An international team of almost 50 experts identified 75 emerging innovations and 8 action points that can help speed up the transition to a sustainable and healthy food system. Their recommendations are published in Nature Food.

At present, 40 percent of global land is used for food production, which contributes to land-use change, biodiversity loss, and greenhouse gas emissions. Thus, major transformations in the way food is produced are necessary. The emerging innovations enumerated include genome editing, vertical agriculture, nitrogen-fixing crops that do not need fertilizer, use of insects for food and feed, among others.

Five out of the eight action points for accelerating the food system transformation are centered on trust, changing mindsets, enabling social license, and safeguarding against unwanted effects. The first point focuses on building trust among key players of the food system which include the farmers, consumers, and food companies. They are required to have shared values on the desirability of various food system outcomes, for example, sustainability provenance, and socio-economic advantages.

Comparative Genomics Helps Reduce Spread of Bacterial Canker in Tomatoes

Plant pathologists from the University of California, Davis, report the use of comparative genomics to identify specific sequences that are Clavibacter michiganensis detection targets. The results are published in Phytopathology journal.

C. michiganensis is a bacterial pathogen that causes bacterial canker disease in tomatoes, which leads to significant losses in greenhouse and field production systems. Thus, the UC Davis team used DNA sequencing data gathered over the past decade to pinpoint particular genetic locations that accurately detect the pathogen causing bacterial canker. By analyzing 37 different strains of the pathogen, they were able to develop a diagnostic platform that can be used without restriction to facilitate the distribution of clean tomato seed to growers.

UPCOMING BIOTECH RELATED CONFERENCES

15th International Conference on Agriculture & Horticulture (Agri 2020),

Date: August 24-25, 2020
Venue: Barcelona, Spain

ICAAC 2020: 14. International Conference on Advanced Agricultural Chemistry

Date: April 24-25, 2020
Venue: Istanbul, Turkey

International Conference on Agricultural Buildings and Plant Protection Technologies

Date: July 20-21, 2020
Venue: Paris, France