

leadership of Yazdi Italia. The organization diagnosed its first patient in 1978, and subsequently, the journey has transformed from misdiagnosis and mistreatment to making Gujarat the first state in India to incorporate the Sickle Cell Anemia Control Programme in 2006. Italia emphasized how this PPP (public-private partnership)-based Gujarat model has become the best-case practice of the nation, which includes colour-coded cards for marriage counselling, free delivery of hydroxyurea, Swa Suraksha programme (a people's movement) to focus on the rural population, etc. This model must be replicated in the entire country.

In pursuance of this model, the Government of MP has initiated the State Hemoglobinopathy Mission in 2021 with a comprehensive plan of action for the elimination of SCD. This aspect was taken up by Ruby Khan (National Health Mission, Bhopal), who elaborated upon the action plan that included provisions in the state budget for screening and management of

sickle-cell patients, strengthening of health facilities (laboratory diagnostics, treatment facility, etc.) and develop a Sickle Cell Portal for digital health record maintenance.

The last lecture of the day was given by Seema Jain (Central Council for Research in Ayurvedic Sciences, Ministry of AYUSH, GoI), who showed the relevance of Ayurveda in controlling and managing SCD. Though SCD is not described per se in Ayurvedic texts, there is a reference to 'Pandu disease', having the same characteristics as SCD in terms of pathogenesis and cardinal symptoms. The treatment is based on preventing hereditary disease and using natural drugs like aloe vera as an anti-inflammatory drug, Guduchi (*Tinospora cordifolia*) as a painkiller, Bhringraj, citrus fruits for vitamin C, etc.

The two-day symposium concluded with a panel discussion with Ravindra Kumar (ICMR-NIRTH) as the moderator. Through this session, various doubts and questions were resolved to bring more clarity to the

participants about the issues related to SCD. The vote of thanks was given by Rajasubramaniam.

1. Brousse, V. and Rees, D. C., *Indian J. Med. Res.*, 2021, **154**, 4-7.

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MEETING REPORT

Weed management*

An international conference was organized to tackle the enormous losses caused by weeds in different agroecosystems and to discuss the future weed management strategies. More than 500 delegates, including eminent scientists, academicians, students, personnel from the pesticide industry and progressive farmers, participated in it. The conference aimed to share knowledge and ideas on available technologies for managing weeds in different agroecosystems and gain input on addressing emerging challenges.

The inaugural address by Himanshu Pathak (ICAR, New Delhi) highlighted the importance of weeds in a sustainable food system and the impact of climate change on weed dynamics. S. K. Chaudhari (ICAR, New Delhi) mentioned the weeds cause an economic loss of around US\$ 11 billion annually in ten major crops in India. Herbicide resistance, pesticide residues, weed flora shift and weed management in con-

servation agriculture are some of the major concerns in modern agriculture. Developing herbicide-tolerant crops, genome editing, bioherbicide and nanoherbicide development, and precision weed management are new areas in weed science. In the keynote address by Trilochan Mohapatra (ICAR, New Delhi), weed population dynamics in a changing climate, nutrient and weed interactions, weed competitiveness and invasiveness, breeding crops for competitiveness to biotic stresses, and the mechanism of herbicide tolerance in weeds were discussed. There is a need to understand gene sequences in weeds. Genetic manipulation, such as RNAi technology, must be introduced to develop herbicide resistance in crops.

The first plenary lecture by Yoshiharu Fujii (Tokyo University of Agriculture and Technology, Japan) on 'Allelopathy utilization for weed control: challenges and perspectives' highlighted the importance of the allelopathy concept in weed management. Nearly 4000 plants and cover crops having allelopathic potential were selected for further utilization. Two traditional cover plants, namely *Mucuna pruriens* and *Vicia villosa* showed allelopathic activity, which are useful for weed management in organic farming. In the next presentation by Prasanta C. Bhowmik (University of

Massachusetts, USA) on 'Bioavailability of allelochemicals in soil environment under climate change: challenges and perspectives', stress was given on the importance of adding crop residues, which will help suppress the allelochemicals through the exudate of allelochemicals. *Brassica nigra*, *Avena fatua*, *Fagopyrum esculentum*, *Secale cereale*, *Sorghum bicolor* and *Triticum aestivum* release allelochemicals such as DIBOA, DIBOA-glycoside, dhurrin, isoflavonoids, isothiocyanate, juglone, momilactone, scopoletin and sorgoleone. The process of new herbicide molecule development was discussed in the next presentation by Shoumo Mitra (Corteva Agriscience, Singapore) on 'Current herbicide development scenario: need to launch reduced risk herbicides'. The pesticide industry emphasises green solutions through reduced-risk compounds and green-chemistry innovations for meeting the farmers' needs and consumers' preferences while protecting the environment and natural resources.

The next presentation by Bhagirath Singh Chauhan (University of Queensland, Australia) was on 'Weed biology: an important science to develop effective weed input on addressing strategies'. To develop an innovative, economical and sustainable integrated weed management (IWM) system, good

*A report on the international conference on 'Weed Problems and Management Challenges: Future Perspectives' held at the Anand Agricultural University (AAU), Anand from 20 to 23 December 2022 and organized by the Indian Society of Weed Science (ISWS), Indian Council of Agricultural Research-Directorate of Weed Research (ICAR-DWR) and AAU.

knowledge of weed biology is essential. Solar radiation and temperature play a major role in breaking the dormancy of weed seeds and their emergence. Weed seeds present on the soil surface germinate earlier than buried seeds. Surface seeds decay faster. Knowledge of weed phenology is critical to understanding weed growth, biomass and level of potential competition. The fourth presentation by N. T. Yaduraju (DWR, Jabalpur) was on 'Non-genetically modified (GM) herbicide-tolerant (HT) rice is now in India'. Recently, scientists in India have developed non-GM rice crops tolerant to the herbicide imazethapyr. These non-GM HT rice varieties (Pusa Basmati 1979 and Pusa Basmati 1985) have wider implications for weedy rice management in direct-seeded rice (DSR) and difficult-to-control weeds like the parasitic weed *Striga*. However, chances of gene flow and development of HR-weedy rice are the major challenges with this technology in the future.

The next presentation by Samunder Singh (International Weed Science Society, USA) on 'Do we see the end of chemical weed control soon?', discussed the current status of herbicide use, challenges in herbicide research, the increasing cost of herbicides and the development of HR weeds. Rapid detection of HR weeds and integrated management options like sterile pollen techniques, crop rotation and diversification, straw management, time and method of herbicide application, herbicide mixtures and irrigation management are needed to manage these weeds.

Biological weed control is becoming popular because of human and environmental health issues and the sustainability of the food production system worldwide. The 'Current status of biological control of weeds and its future perspectives' was discussed by Martin P. Hill (Centre for Biological Control, Rhodes University, South Africa) in the next presentation. Until 2018, there have been 1555 international releases of 468 biological control agent species, used against 175 species of target weeds in plant families in 90 countries. Socio-economic studies indicated that nearly US\$ 1 billion could be saved by using biological weed control. It also helps in ecosystem recovery.

The next presentation by Muthu Bhagavathiannan (Texas A&M University, USA) was on the 'Application of digital technologies for weed detection and precision management'. Site-specific weed management is an effective strategy for improving management outcomes, enhancing resource-use efficiency and achieving long-term sustainability. Weed recognition and iden-

tification can be accomplished through machine learning by field-image collection through synthetic image generation (artificial image), deep learning (CNN-based models), 3D modelling of weed features and generative adversarial network (GAN) aided with their management by drone-based herbicide applications.

The presentation by T. K. Das (IARI, New Delhi) on 'Weed management in conservation agriculture (CA): Challenges and perspective' emphasized the long-term effect of CA technologies on weed dynamics. CA reduces weed pressure in terms of total weed density but increases weed diversity and weed shift in rice- and maize-based cropping systems. The CA system results in shifting towards perennial weeds, but annual grassy weeds like *Phalaris minor* in wheat are reduced considerably. The infestation of *Cyperus esculentus*, however, increased tremendously in different CA-based systems after eight years. In the next presentation by Shobha Sondhia (DWR, Jabalpur) on the 'Herbicide residues in soil, water and plants: mitigation challenges and the future perspectives' highlighted the chronic effect of atrazine, 2,4-D and diuron on marine species and coral ecosystems. Virendar Kumar (International Rice Research Institute, the Philippines) spoke about weed management in small holder rice in Asia: Challenges and opportunities.

The evolution of herbicide-resistant weeds was discussed in the talk by Amit J. Jhala (University of Nebraska-Lincoln) on 'Pollen-mediated gene flow (PMGF) and transfer of herbicide-resistant alleles from herbicide-resistant to susceptible weeds'. Interspecific hybridization studies within *Amaranthus* and *Ambrosia* species showed that herbicide resistance allele transfer is possible between species of the same genus but at relatively low levels. The occurrence of herbicide-resistant weed populations and high genetic diversity is partly due to PMGF, particularly in dioecious species such as palmer amaranth (*Amaranthus palmeri*) and water hemp (*Amaranthus rudis*), compared with monoecious species such as common lamb-quarters (*Chenopodium album*) and horseweed (*Conyza canadensis*). The next presentation by P. J. Khankhane (DWR, Jabalpur) was on the 'Performance of weedy plants in decentralized constructed wetland systems and their potential of post-harvest biomass utilization for bio-energy production'. The weedy plants such as *Phragmites karka*, *Typha latifolia*, *Arundo donax*, *Vetiveria zizanioides*, *Canna indica*, *Eichhornia crassipes* and *Pistia stratiotes* can be used for water treatment

in decentralized subsurface and surface-constructed wetlands. After phytoremediation, the post-harvest biomass of *Typha* can be utilized in biogas production. Detailed discussions on various issues resulted in the following recommendations for strengthening research to address future challenges in weed management.

(1) There is a need to incorporate traditional knowledge and wisdom in developing modern tools and techniques in weed management.

(2) Studies on weed population dynamics, weed competitiveness and invasiveness, and breeding crops for competitiveness to biotic stresses should be promoted.

(3) More emphasis should be given to nanotechnology, microbial and bioherbicide products, and identification and import of host-specific potential bioagents for biological control of alien invasive weeds.

(4) Emphasis should be given to identifying the promising allelochemicals for weed suppression in organic farming. The persistence and availability of these allelochemicals in the soil environment need to be studied.

(5) Research on the application of digital technologies for site-specific weed management should be taken up.

(6) The impact of climate change on weed dynamics, weed competitiveness and herbicide efficacy should be examined.

(7) The long-term impact of CA on pest dynamics and weed seedbanks should be studied in major cropping systems. Management strategies for difficult-to-control weeds in CA should be formulated.

(8) Focused research on identifying herbicide-resistant weeds, the molecular basis of herbicide resistance and their management strategies should be taken up.

(9) Research on the development of non-transgenic HT crops and stewardship programmes should be initiated.

(10) Science-based reviews of various herbicide molecules, which have been in use in India for several years without any adverse effects, are required to enable policy-makers as well as regulatory authorities to make pragmatic decisions before banning/prohibiting various herbicide molecules.

(11) As weeds are one of the major biotic stresses in agriculture, a basic course on weed science at the undergraduate-level degree programme in agricultural universities should be included.

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