Evaluation of herbicide resistance in different biotypes of *Phalaris minor*

Herbicides are the foundation of weed control in modern agricultural production systems. The evolution of herbicide-resistant weed populations is a natural response to selection pressure imposed by such agricultural production technologies. Resistance of weeds to herbicides is an undesirable secondary effect produced after repeated use of the same herbicide, where a specific weed population is no longer controlled with the same efficacy by the herbicide. Evolution of resistance or avoidance is also favoured when a particular management practice is repeated over a period of time without any diversification. There are currently 416 unique cases (species × site of action) of herbicide-resistant weeds globally, with 222 species, including 129 dicots and 93 monocots. Weeds have evolved resistance to 21 of the 25 known herbicide sites of action and to 150 different herbicides. Herbicide-resistant weeds have been reported in 74 crops from 63 countries.

Resistance in *Phalaris minor* to isoproturon application is the only reported case so far in India since the first report in the early 1990s. This is now common throughout the Indo-Gangetic Plains, covering more than 1 m ha of wheat-growing area. Recently, some of the populations of *P. minor* have also evolved multiple resistances to three modes of action (photosynthesis at photosystem II site A, ACCase and ALS inhibitor). However, these multiple resistant populations are sensitive to triazine (metribuzin and terbutryn) and dinitroaniline (pendimethalin) herbicides. The dependence on herbicides has contributed to the rapid evolution of multiple herbicide resistance, and integrated weed management strategies must be adopted to ensure the sustainability of crop production. The long-term strategies comprising suitable crop rotation, herbicide rotation and sanitation practices (weed-free crop seeds and manure) along with other agronomic tactics (competitive variety, early sowing, higher seed rate, zero tillage, stale seedbed, etc.) need to be integrated for effective management of herbicide-resistant weeds.

We have initiated a research programme on 'Weed management in the context of herbicide resistance' to study the physiological and molecular aspects, especially in species like *P. minor* and *Echinochloa crussgalli*. Such aspects should receive greater attention of weed scientists as the use of herbicides is finding rapid acceptance among farmers throughout the country.

Herbicide-resistant biotypes of *Phalaris minor* at DWSR farm.

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MEETING REPORT

Endocrine disruptors*

The endocrine system in our body along with the hormones they secrete is unique and crucial for our life events such as metabolism, mood, pregnancy and growth and development of organs.

The endocrine glands, including the pituitary, hypothalamus, pineal, thyroid, parathyroid, adrenal, thymus, pancreas, ovaries and testes, release specialized hormones into the bloodstream that act as natural chemical messengers, travelling to different parts of the body in order to control and adjust many life functions in a concerted and coordinated way. Because of the central role of hormones in the proper functioning of the body, disruption of the endocrine glands and hormone signalling can cause a wide range of health problems. In the last few decades, there is an increasing awareness on the health hazards posed to both humans and wildlife by certain xenobiotic compounds which interfere with the hormonal system. Generically, these compounds are described as 'endocrine disruptors' and due to their potential hazard, they have received great attention by the scientific community and the media. The endocrine disrupting chemicals are widely used in consumer products, including plastics, food packing materials, cosmetics and medical devices and thus are extensively interwoven with human day-to-day life usages. Although the list of endocrine disruptors is a long one, it majorly includes the following:

*A report on the one-day seminar on 'Endocrine Disruptors' organized by the Department of Endocrinology, Dr A.L.M. P.G Institute of Basic Medical Sciences, University of Madras, Chennai, on 15 March 2014.

alkylbenzenes, alkylphenols, bisphenols, chlorophenols, benzenes, furanes, dioxins, phthalates, triazines, triazoles and pesticides (DDT derivatives and metabolites, carbamates, dithiocarbamates, organophosphates). The US Environmental Protection Agency (EPA) was the first to react on the research needs relative to future risk assessments for endocrine disruptors and this has been followed by many European and other countries. Unfortunately, the importance of research related to endocrine disruptors, the need for filling the major scientific data gaps and the policy-related Government regulations are less addressed in India at a major level. The one-day seminar on 'endocrine disruptors' helped bring together basic scientists, clinicians and policy-makers on a single platform to address the health hazards of endocrine disruptors. The seminar offered several new biology insights into the harmful effects of endocrine disrupting chemicals on human health.

The impact of endocrine disrupting chemicals on humans and wildlife was addressed by O. V. Oommen (Kerala State Biodiversity Board, Thiruvananthapuram). The valuable contribution of flora and fauna of the Western Ghats to human welfare and the influence of environmental chemicals on the extinction of wildlife formed the focus of his lecture. His optimism for the future lies in educating the public about the need for nature conservation. He emphasized that both nature conservation and the discriminate use of environmental contaminants are intimately linked with the quality of human life and disease-free future.

M. Balasubramanyam (Madras Diabetes Research Foundation, Chennai) spoke on 'Endocrine disruptors – adding fuel into the etiology and epidemic of diabetes'. Quoting the recent Atlas of the International Diabetes Federation, he said that as on today India harbours more than 65 million diabetics. He underscored the importance of the environment and not just genetics for the spread of diabetes. While emphasizing the fact that several 'tissues are issues' in the molecular pathogenesis of diabetes, Balasubrmanyam pointed out the plausible tissue-specific effects of endocrine disruptors on adipose, skeletal muscle, pancreas, gut, heart, brain, liver and kidney. Quoting several epidemiological studies and meta-analysis data, he claimed that there is a strong association between type-2 diabetes and persistent organic pollutants. While the epidemiological data indicate that exposure to endocrine disrupting chemicals is linked to an increased risk of diabetes mellitus in humans, data obtained from pregnant mice and offspring indicate that short exposure to the persistent organic pollutants during pregnancy disrupts glucose homeostasis in female mice and their adult male offspring. Balasubramanyam cautioned that the risk of diabetes in both pregnant women and their offspring in adult life, is connected to epigenetic mechanisms and endocrine disruptors could be one such epigenetic modulator. He also brought to the notice of the participants a report 'State of the science of endocrine disrupting chemicals' by an international team of experts compiled under the auspices of UNEP (United Nations Environment Programme) and WHO (World Health Organization), which provides a thorough evidence linking hormone-mimicking chemicals to human health problems.

Illustrating several *in vivo* animal model studies, B. Kumaran (KMPG Centre for Zoology, Tagore Arts College, Puducherry) reported that hexaconazole (a fungicide) promotes male infertility in rats. He also mentioned that carbendazim (methyl-2-benzimidazole carbamate), a metabolite of benomyl is one of the most widespread environmental contaminants of major concern to human and animal reproductive health. Narayana Reddy (Dega Institute, Chennai) spoke elegantly on 'Love and hormones'. He emphasized that what we call love is the most exhilarating of all human emotions and is probably nature's beautiful way of keeping the human species alive and reproducing. With an irresistible cocktail of chemicals, our brain entices us to fall in love. The love and sex hormones list goes like this: testosterone, oestrogen, adrenaline, dopamine, serotonin, oxytocin and vasopressin. He cautioned that endocrine disruptors can interfere with the levels and action of these hormones and thereby negatively influence sexual and reproductive health in both men and women. He highlighted environmental contaminants that disrupt hypothalamic–pituitary–testicular axis, which could be the contributing factor for the increasing prevalence of infertility.

While the seminar provided an opportunity for graduate students and young researchers to learn from experts in the field of endocrine disruptors, it also paved way for the following specific recommendations.

(1) Three strands of evidence fuel concerns over endocrine disruptors: (a) The high incidence and the increasing trends of many endocrine-related metabolic disorders in humans; (b) Observational evidence of endocrine-related effects in wildlife populations. (c) Identification of chemicals with endocrine disrupting properties linked to disease outcomes in laboratory studies. Therefore, research on the multi-faceted effects of endocrine disruptors becomes the most challenging globally and in India, in particular.

(2) It is important for the Government of India to set up an exclusive laboratory to analyse synthetic chemicals for endocrine-disrupting effects through the Endocrine Disruptor Screening Programme.

(3) Funding agencies should encourage research work on endocrine disruptors by setting up a special task force. The immediate research agenda should look at the following: development of large-scale screening techniques for measuring endocrine disruptors in serum, plasma and other tissue samples; determining the molecular mechanisms of action of endocrine disrupting chemicals; characterization of trans-generational and epigenetic effects of endocrine disruptors; population-based cross-sectional and prospective studies with disease-focus, to name a few.

(4) Scientists and clinicians must help educate law makers and the public about the threats of endocrine disruptors as well as the means to limit their impact through sound government policy and smart consumer choices.

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