

## **SOLVING WEED PROBLEMS THE ASIAN-PACIFIC WAY: PAST AND THE FUTURE**

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### **ABSTRACT**

*In this review article we provide a brief summary of history and achievements of Asian-Pacific Weed Science Society (APWSS) and contributions it has made to weed science. The vision and objective of promoting weed science, particularly in Asia and Pacific region, have been primarily achieved through well attended biennial conferences, topical symposia and workshops, training courses, affiliations/collaborations, newsletters, and establishment of an international journal. We also highlight some of weed problems of region, the ever changing research needs over time, the major scientific challenges for future, and suggest ways in which Society can further assist its members and weed science in years to come.*

**Key words:** Weed research, weed management, APWSS, regional society, herbicides

### **INTRODUCTION**

The Asian-Pacific Weed Science Society (APWSS) came into existence in 1967 when some 87 delegates from 22 countries participated in first Asian-Pacific Weed Control Interchange in Honolulu, Hawaii. The credit for facilitating this interchange must go to East-West Center of University of Hawaii and to founding fathers (in particular Drs W.R. Furtick, D.L. Plucknett and R.T. Romanowski) for their vision, enthusiasm and hard work. The theme for that first Conference, held under the chairmanship of Dr. Marcos Vega of Philippines, was "Weed control basic to agricultural development" and how true it remains even today. Dr. Don Plucknett was elected Secretary in 1967 and was in that role for 14 years, but continued to support Society in many ways over a longer period. The staff from the University of Hawaii and International Rice Research Institute/University of Philippines provided much support, ensuring continued progress of APWSS and establishing linkages with colleagues in Asia-Pacific region.

The primary objective during first meeting was to "facilitate interchange of current weed control information and to promote research in weed science". The desired outcomes, according to Dr.

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Plucknett, were to identify: (a) the weed workers in the Asian-Pacific region; (b) the major weeds and weed problems; (c) the research and development needs of various countries in region, and (d) the linkages necessary or possible in dealing with the perceived needs. A news release on 3 July 1967 by East-West Center, after first Conference stated. The Society will seek to stimulate research into how extensively weeds limit food production in tropics, giving major attention to rice in Asia and to coconuts in Pacific.

The objective as set out in current Rules of APWSS is "To promote weed science, in particular in Asian and Pacific regions, by pooling and exchanging information on all aspects of weed science". The aim of this presentation is to look back and see how well we have achieved the vision and objectives set out for APWSS, the contributions our Society has made to the Asia-Pacific region since 1967, and to discuss possible future challenges and research needs. In preparing this manuscript, we have made extensive use of publication "APWSS: Commemorating Forty Years" (Baltazar, 2007) and also consulted with a number of colleagues who have supported and contributed to Society for many years. The information presented provides only a few examples of activities and achievements of which there are too many to mention here. The examples included are at random and focussed more on cropping weed problems.

### **Delivering on its objective**

Society has delivered extensively on its prime objective of promoting weed science in Asia-Pacific region, by pooling and exchanging information. This has been done primarily through its biennial conference held regularly in different countries. The efforts have been enhanced through occasional workshops and symposia, held as necessary, which brought together many experts including some from out of region. Two famous books viz: "The World's Worst Weeds" and "A Geographical Atlas of World Weeds" have been co-authored by APWSS founding members (Leroy Holm, Juan Pancho, Donald Plucknett and Horace Clay) with support from APWSS and the East-West Center at University of Hawaii. The international journal Weed Biology and Management, first published in March 2001, (and now in its 11<sup>th</sup> year) was published by the Weed Science Society of Japan Inc., with support and encouragement from various national weed science societies affiliated with APWSS. The above, and some additional activities that have helped in achieving aims of the Society, are summarised below.

### The Biennial Conferences

Since first meeting in 1967, a conference has been held every two years hosted by different countries in region. The only exception was 22<sup>nd</sup> Conference which was held in March 2010 (instead of 2009

as planned) due to some organisational difficulties. The number of participants attending each conference increased from 87 founding members in 1967 to about 300 in 1980's, peaking to 589 in 1989. The number of papers also increased from 50 in 1967, peaking at 223 in 1999. The quality of Conference proceedings has also improved substantially, with some Conferences producing two large volumes. The number of countries participating was lowest (8) in 2010 and the highest (27) in 1997, with some participants from outside the Asia-Pacific region.

#### Symposia and Workshops

Some examples include:

1. The first symposium on integrated control of weeds was organised in 1975 as a component of the 5<sup>th</sup> Conference programme in Tokyo, Japan.
2. APWSS sponsored "International Symposium on Wild and Weedy Rices in Agro-ecosystems" which was held in Vietnam in August 1999.
3. An APWSS-sponsored FAO/IWSS Expert Consultation on Improving Weed Management in Developing Countries Workshop was held in Rome in 1982 where an FAO Panel of Experts for Weed Science was appointed.
4. A satellite workshop of the 18<sup>th</sup> Conference in 2001 on "Control of *Echinochloa* species" was held in May 2001, co-sponsored by APWSS at FAO.
5. The Asian-Pacific Herbicide Resistance Working Group was formed in 2001 (chaired by Dr. K. Itoh) to manage herbicide resistance and search for solutions to resistance problems in the Asia-Pacific region.
6. A FAO-APWSS pre-Conference sponsored workshop on "Control of Cyperaceae Weeds" was held in 2005 in Vietnam.

#### Training

Several organisations in Asia-Pacific region have been active in organising training courses and seminars with assistance from APWSS. Notable among these include (i) East-West Center of the University of Hawaii, started around 1961 to increase understanding among nations through cross-cultural interchange in an academic setting; (ii) Regional Center for Tropical Biology (BIOTROP) in Indonesia, established around 1968, which has provided both intensive courses as well as long term research training courses in weed science: in the mid-1980s it established the Southeast Asian Weed Information Centre to assist the weed scientists of the region; (iii) International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, which has provided training and invested considerable research effort to develop improved farming systems (including management of weeds) for small farmers of limited means. They have shown how cropping system itself can be manipulated to improve weed control. A couple of specific

examples include (i) 'Weed Science in the Asian Tropics' sponsored by APWSS and Weed Science Society of Japan, held in Thailand in 1995; and (ii) the international seminar on 'Weed Management in the North Asian Region', Co-sponsored by APWSS, held in China in 1996.

#### Newsletters

To enhance the communication between Society members, idea of an APWSS Newsletter was discussed around 1973 and Philip Motooka was appointed as Editor of the first Newsletter. Since then an average of 4 issues have been published biennially (up to 7 issues between 1977 and 1979). Unfortunately, there was a brief pause between 2005 and 2008 until Dr. Nimal Chandrasena gave it a new lease of life and has kept it going since then. Former editors have included Drs. Beatriz Mercado, Aurora Baltazar, John Swarbrick and Yasuhiro Yogo. These Newsletters have included news items from member countries, activities of members, developments in industry, information on specific weeds as well as current research being conducted by weed scientists of the region.

#### Awards and Travel Grants

APWSS, in cooperation with international chemical company Monsanto, established Best Paper and Best Poster competition which ran for 20 years, from 1983 to 2003. The aim of this competition was to recognise and encourage high quality research in weed science and related fields in the region. During each Conference three Best Papers (oral) and three Best Posters were selected by a panel of judges. These high quality presentations reflected the progress of weed science in region and highlighted research problems prevalent at the time. The award included a plaque and a cash prize.

The Young and Deserving Scientists Travel Grant was initiated in 1987 to give partial support to members to present at APWSS Conference. Full implementation of this Grant occurred in early 1990s and it has been in operation since then.

The first APWSS honorary life member, Y. Baron Goto, was elected in 1973. Since then many others have been added to list. At 20<sup>th</sup> anniversary of APWSS in 1989, a special programme was held to honour and recognise founding members, charter members and past presidents, for their contributions to Society. A special citation was presented to Don Plucknett who was one of the three founding fathers of APWSS in 1967.

#### Affiliations/Collaborations

The Weed Science Society of Indonesia was first national society to become affiliated with APWSS around 1971. This number grew quickly to 6 by 1973 with affiliation of national societies of USA, Japan, India, New Zealand and Australia. With constant encouragement and support of APWSS, more national societies were

established and by 1989 there were 13 national societies represented at its Executive Committee meeting. The Weed Science Society of Vietnam and the Plant Protection Society of Sri Lanka were added to the list in 1997 and 1999, respectively. The latest, Weed Science Society of Bangladesh, was formed in 2008. APWSS became an affiliate of the International Weed Science Society (IWSS) in 1975 and, when first set of officers for IWSS was installed during 1977 business meeting of APWSS in Indonesia, L.J. Matthews of New Zealand was appointed its first President and S. Matsunaka of Japan became APWSS representative. In 1987 the Weed Science Society of America (WSSA) and APWSS agreed to establish an official exchange of conference delegates to promote closer contact between two societies. The first official WSSA delegate was Richard Schumacher and APWSS delegate was Yuh-Lin Chen.

### **An early start to weed research**

The major research efforts of weed scientists in Asia-Pacific region have revolved around: (i) identifying major weed problems; (ii) understanding their taxonomy and biology; (iii) controlling or effectively managing them, which has often included investigating the most effective herbicide, and in later years; (iv) assessing unintended environmental, human and off-target impacts of various control measures. Our region has kept pace with developing technologies in weed management, although, without adequate infrastructure, introduction and uptake of some technologies has been slower. For example, presentations at New Zealand's National Weeds Conferences in 1948 and 1949 included papers on phenoxy herbicides and subjects such as low volume nozzles and low volume spraying of pasture weeds. Similarly K. Noda and K. Ozawa mentioned at 3<sup>rd</sup> APWSS Conference that 2,4-D was introduced into Japan in 1950. By early 1960s, herbicides belonging to groups such as phenoxy, amides, carbamates and dinitroanilines were introduced into many countries of the Asia-Pacific region. However, as observed by W.R. Furtick in his plenary paper at 1<sup>st</sup> APWSS Conference, "...until 1960s unfortunately there has not been this same level of effort in tropical and semi-tropical areas" (as in temperate zone crops).

### **The problems of the region**

The number and diversity of weed problems are much greater in tropical agriculture than under temperate zone conditions. Weeds present a problem over a much longer period of the year or even all year round. This was echoed by following statement from the IRRIS 1965 Annual Report which said on page 227 "An important reason for low yields of most upland rice is the absence of effective low-cost weed control". So how true was the theme of the 1<sup>st</sup> Conference in 1967 "Weed control basic to agricultural development"? There is no

doubt that conflict between humans and weeds will continue, so long as humans modify ecosystems.

At 2<sup>nd</sup> APWSS Conference in 1969, Leroy Holm suggested "...there are about 200,000 species of angiosperms recorded.... Some estimates suggest that 30,000 of these may behave as weeds. We have looked at 3000 and were able to reduce the list of weed species to 100.... *Cyperus rotundus*, a native of Asia, may be the world's worst weed. It is in all of the major crops and most of the important agricultural regions of the world....".

In rice, the most important crop of our region, *Echinochloa crus-galli* probably received most attention on its impact and control as well as taxonomy. *Phalaris minor* became such a menace in wheat crops that it threatened the sustainability of rice-wheat cropping systems in countries like India. Control strategies for these and many other weeds in crops like rice, wheat, maize, sorghum, pulses, vegetables, sugar cane, pineapple etc. have been investigated and reported. Management of weeds in plantation crops has been reported from researchers in many countries as have pasture weeds, especially from Australian and New Zealand scientists. Aquatic weeds are distributed throughout the region and much research on their mechanical, chemical and biological control (as well as their beneficial uses) has been reported for species like *Eichhornia crassipes*, *Salvinia molesta*, and *Alternanthera philoxeroides*. The noxious weeds of non-agricultural land such as *Imperata cylindrica*, *Mimosa pigra* and *Lantana camara* have also posed considerable threats and have been the subject of many investigations. Additionally, biosecurity issues and the spread of invasive weeds like *Parthenium hysterophorus*, *Mikania micrantha*, and *Chromolaena odorata* have received much attention as they are likely to have a serious impact under predicted climate changes. It is not possible to list here even the most important weed species of the region, but some further problem weeds are mentioned in later sections.

### **The Ever Changing Research Needs**

With discovery of selective herbicides, efforts of weed scientists accelerated towards a 'weedless' agriculture. If efforts on chemical weed control were successful, it was predicted by D.L. Umali at 2<sup>nd</sup> Conference held at IRRI in 1969 "..... in after years it will be a great source of pride for us to say that on these grounds was held meeting that spelled doom of weeds in agriculture..." The weed species, or at least some of these, by their nature, have defied most predictions and continued to evade, shift, evolve and survive.

Noda and Ozawa mentioned at 3<sup>rd</sup> Conference in 1971 that, by late 1960s in countries like Japan, nearly total area of paddy fields were being treated with herbicides. The famous Green Revolution of

1960s gave Asia-Pacific region in particular, the short statured high yielding varieties of rice and wheat which required very high levels of weed control for best performance. This, combined with increased irrigated areas and introduction of more effective herbicides, encouraged farmers in many countries to shift from transplanted to direct seeded rice. Unfortunately, water regimes in direct seeded rice caused a shift in weed flora to more competitive grasses and some very difficult to control broadleaf weeds. Such shifts, along with increasing costs of labour and quest for greater economic returns, saw introduction of many new pesticides during last 3 decades of 20th century. Availability of new herbicide chemistries (eg aryloxyphenoxys, sulfonyleureas), with very low use rates, saw shifts from sequential applications in 1970s to one-shot treatments by late 1980s. Similar, although maybe not so elaborate, developments could be related for many other crops in the region.

Herbicides thus became an indispensable part of modern agriculture in most countries of the region. They reduced yield losses due to weed competition and provided the foundation for protection of yield potential. They also helped to prevent erosion caused by tillage and have had a direct impact on the exploitation of human labour in poor countries of our region. Two major problems, (i) concerns for environment and human safety, and (ii) appearance of herbicide resistant weeds, led to devaluation of herbicides and questioned sustainability of this technology developed over last 50 – 60 years. A large volume of research on environmental impacts of herbicides on soil and water resources has been conducted in region and efforts have been made to optimise herbicide regimes, doses and application techniques to mitigate the adverse impacts (eg. Rahman and James 2002). A gradual reduction in efficacy (accelerated degradation) of certain herbicides as a result of their continued use has also become an issue in some cropping systems.

Herbicide resistance became a subject of discussion within East, Southeast Asia and Australia in early 1980s. Sulfonyleurea resistant sedges, broadleaves, and 2,4-D and triazine-resistant broadleaf weeds, were among first to appear on scene. Propanil-resistant *E. crus-galli* and isoproturon-resistant *P. minor* were subject of many research papers. Resistance to sulfonyleurea herbicides had developed in nine annual weeds and three perennial weeds found in rice cultivated areas in Japan, and for some of these resistant biotypes, the herbicide dose for 50% mortality was found to be 100 to 1000 times higher than that for susceptible biotypes (Itoh, 2005). In Australia, greatest number of occurrences of herbicide resistance has been for *Lolium rigidum* growing as a weed in continuous cropping rotations (usually wheat/lupins). In New Zealand, development of resistance to

phenoxy herbicides in three pasture weeds poses a special difficulty for their selective control because pastures usually contain a mixture of two sown species viz. grass and legumes (Rahman et al. 2001). Today weed resistance problems have achieved a dramatic magnitude and they are ever increasing all over the world.

For a majority of countries in Asia-Pacific region, weedy rice or red rice emerged as a new and possibly most dangerous weed. It has recently been reported as the major pest that currently threatens rice production in Vietnam (Chin and Thi, 2010). First noted in 1988 in Malaysia, it had infested many fields there by 1993 (Vaughan et al., 1993). It has same scientific name as cultivated rice (*Oryza sativa*), but it has some weedy characteristics such as easy shattering and a red pericarp. Weedy rice has a short life span, is a tall plant, with weak culms and small seeds. The origin of weedy rice is not certain. It may have originated from degradation of cultivated rice or may have come from crossing between cultivated rice and wild rice.

Persistent reports on negative environmental impacts, concerns about human safety and ever increasing number of herbicide resistant weeds shifted research emphasis from chemicals to integrated, ecological and biological approaches to manage weeds. So since 1990s, Integrated Weed Management (IWM) and sustainable agriculture became subject of discussion of many presentations. It is interesting to note, however, that back in 1975 the theme of the 5<sup>th</sup> Conference held in Japan was 'Integrated Control of Weeds'. Also starting from the 13<sup>th</sup> Conference in 1991, at least six APWSS Conferences have had the word 'Sustainable' included in their theme. Increased effort also went into developing botanical and biological weed control agents including mycoherbicides.

Genetically modified (GM) crops, however, resulted in a big shift towards less emphasis on herbicide research. As a consequence, investments in research to discover new modes of action have decreased precipitously. Who would have thought that by year 2000, 66% of soya bean production in USA would contain a gene that confers resistance to glyphosate. For most important crop of our region viz. rice, commercial developments have taken place for three herbicide resistant varieties: Clearfield (imidazolinone resistant), Roundup Ready (glyphosate resistant) and Liberty Link (glufosinate resistant), with genes for resistance derived from different sources (Baki, 2005).

Today, emphasis in some countries has turned from weed control as such towards vegetation management using environmentally acceptable, yet economically effective remedies resulting from integrating management strategies. To meet these changes increased effort has gone into knowledge-based decision-support approaches such as expert systems and simulation models.



Expert systems have many predictive and diagnostic applications in weed control, particularly in the development of integrated approaches to crop management. While waging a protracted war on weeds, we need to keep exploring the potential for using some of them as resources, such as food for humans and animals, raw materials for a range of products, bio-fuels, phyto-remediation and further exploiting the chemical warfare between plants (allelopathy).

### **Major future scientific challenges for the region**

As mentioned in above Section, much has happened in weed science within Asia-Pacific region since Society held its first conference. As examples, we have had new herbicide chemistries, herbicide safeners, application technologies, herbicide resistance in weeds, accelerated degradation of herbicides, greater concern about effects of herbicides on environment and safety to humans, biological herbicides, genetic engineering and the move towards developing integrated sustainable weed management strategies. Many of these problems are going to confront us for years to come and new challenges are going to arise. In future, weed scientists in our region need to promote research in following areas (and the list is by no means exclusive or exhaustive):

- Integrated management of weedy rice, which is threatening productivity of major staple food crops of most Asian countries
- Continued risk assessment and monitoring of existing and new herbicides
- Accelerated development of practical and economic strategies for control of herbicide resistant weeds
- Sustainable weed management strategies for GM crops to stop the potential emergence of "super weeds"
- Sustainable weed management under residue-rich conservation agriculture, such as zero and minimum tillage
- New targeted and precision application technologies and site-specific weed management for minimising herbicide dosages
- More effort on developing biological agents including natural products and mycoherbicides for emerging weed problems, particularly in the non-crop situations
- Expansion of expert systems for weed management and precision agriculture technology through greater use of GIS, GPS and remote sensing
- Utilisation of weeds, both terrestrial and aquatic species, as discussed in detail recently by Chandrasena (2008)
- Mechanisms and preventive measures against globalisation of invasive alien species such as *P. hysterophorus*, *M. micrantha* and *M. pigra*, due to increased international trade, transport and tourism

- Impact of climate change on weeds and their management strategies
- Targeted and effective extension/technology transfer to end users for a faster uptake of improved management options.

APWSS has played an extremely important role by connecting so many people from diversified parts of world and providing a vibrant forum for exchange of weed science information. In a speech acknowledging his special citation for APWSS mentioned at 12<sup>th</sup> Conference in 1989, D.L. Plucknett, the founding father, said,...."I have always been proud of what the Society has been able to achieve. I have been told that APWSS is now the largest regional Weed Science Society in the world...". We wholeheartedly echo his words regarding achievements of APWSS. The Society can further assist in coming years, by: (i) organising/facilitating regional workshops on specific topics; (ii) supporting publication of special issues of journal Weed Biology and Management to deal with specific areas; (iii) formulating and encouraging networks/working groups for widespread problems such as weedy rice and herbicide resistance; (iv) linking up young weed scientists with industry and internationally recognised institutions; (v) providing advocacy for adequate education and research grants in weeds science; and (vi) being at forefront of identifying emerging issues of weeds and creating opportunities for employment of long-term solutions to weed problems. Most of all, Society can take an active role in making the public aware of factors that may endanger agricultural production systems being able to keep pace with increasing demand for food – weeds being among the biggest threat at the top of the list.

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