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SHAPING THE FUTURE OF WEED SCIENCE TO SERVE HUMANITY IN THE ASIA-PACIFIC

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ABSTRACT

The Asian-Pacific Rim comprises of farming communities with contrasting economic and agricultural development. With population exceeding three billions with significant differences in socio-economic, technological and digital divide, the economic well-being of the farming communities and consumers is always a difficult and perennial issue bothering political powerhouse, policy makers, agricultural scientists, extension agents and farm managers alike. It is a truism that the story of agriculture is also the story of weed interference. Weeds continue to be a perennial and constant threat to agricultural productivity, despite decades of modern weed control practices aimed at their elimination. Weeds, especially invasive ones, affect agricultural production, forestry, human health, the aesthetic quality of non-crop lands such as lawns, and parks, conservation areas, rights-of-way, drainage and irrigation canals, and other waterways, and rangeland. It is the objectionable nature of weeds arises from the reduction of food quantity and quality produced by crop systems primarily that has become the central focus of most research within the weed science fraternities worldwide. The control of agronomic weeds is a recognized necessity in order to maintain high levels of productivity in an increasingly globalized agricultural economy. While free trade devoid of tariffs and quotas promises to improve the world economy, it will create more and more pathways for movement of invasive species into new environments in different parts of the world. The homogenization of the world's flora and fauna and the lingering effects of introduced invasive species are unintended side effects of accelerating globalization. Both pose a consequential threat to agricultural sustainability, and managed production systems, and to ecosystem biodiversity. The development of herbicide-resistant weeds and weed population shifts continue to challenge the effectiveness of modern weed management practices. Because of the complexity of weed community, integrated approaches to weed management techniques fortified with scientific knowledge in a manner that considers the causes of weed problems rather than reacts to existing weed populations should be practiced with the goal to optimize crop production and grower profit through the concerted use of preventive tactics, management skills, monitoring procedures, and efficient use of control practices. Evidently, there is a dearth of information and a plethora of data showing the incremental benefits of judicious use of herbicides integrated with cultural, mechanical, and biological means in managing weeds, with high yields, yet minimized environmental

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impact. Weed scientists while facing complex and difficult challenges, must increase the sustainability of our current management approaches and help respond to invasive plants as a component of global change. Any effective response to these challenges will require participation and practice of public scholarship by weed scientists in addressing professional priorities. The future of weed science as a platform in serving humanity is dependent on a joint effort from industry, government regulators, and private and public sectors consisting of grower groups, department of agriculture, the universities and research institutions. I am of the opinion that weed science will be better positioned in serving humanity within the context of maintaining food security, and environmental safety, if research focus emphasize on research decision processes, weed biology and ecology, weed control and management practices, herbicide resistance, issues related to transgenic crops, environmental and health issues, and potential benefits of weeds. In the same vein, efforts spent on these research areas have benefited and will continue to benefit, not only growers, commodity groups, homeowners, and industry, but also society at large, through the maintenance of food and fiber production system, and environmental safety of agro- and non-agro-ecosystems worldwide.

Keywords: Asia Pacific, globalization, herbicide resistance, perennial weeds, environmental safety, weed science.

INTRODUCTION

"If there is no man,
there will be no woman,
If there is no agriculture,
there will be no mankind" (Baki, B.B. 2005)

The world's great civilizations, the root of what we call the developed world, are all based on agriculture. Agriculture is farming, fishing and ranching, and it is growing something for human needs and welfare. Agriculture is hard work and drudgery. It is what some must do, but it is *not* what most wants to do. Food production is not just hard work, it is a business, and it is profitable. In many Asian-Pacific countries, agriculture is still the mainstay of the national economy. This economic pursuit is prevalent and will be permanently relevant to feed the growing populace. Despite differences in emphasis in the economic activities in different countries, food security and food safety (FSFS) is in the top notch of economic and political agendas for policy makers, farmers, and farm managers alike. Agriculture is the most far-reaching land use changes in the transformation of vast areas of the Earth's surface. Today the ability of agriculture to produce enough food and fiber for the world populace is primarily dependent on modern weed science.

I am in the opinion that whatever shapes, the future of agriculture will also shape and impact the future of weed science. In this respect, the status of the natural resource base; climate change the extent of desertification and land degradation, advances in science andtechnology;urbanization;trade liberalization and commercialization; and strategic alliances and international agreements and conventions will impact agricultural development and weed science development and practices in the Asia Pacific.

The ensuing discussion in this paper will focus briefly on (i) managing strategy for weeds in agro-ecosystems; (ii) future research directions for weed science; (iii) standard operating procedures (SOPs) for research in weed science; and (iv) the ethics of weed science research, with reflections on (i) nature of weed research and scholarship; (ii) effective and ethical professional practice by weed scientists within broader contexts of agriculture and agricultural science, and (iii) roles of weed science in the service of humanity. The paper ends with note on future trends in weed science and challenges facing weed scientists in the Asia Pacific region.

WEEDS, AGRICULTURE AND MAN IN THE ASIA PACIFIC

"In the beginning, there were no weeds" (Baki, 2006a).

Weeds, Agriculture and Man: The Relationship

Weeds are not an innocent entity as they look. They can evolve, and they have! Weed is a human construction, its origin is man-made, just as hoes and herbicides used to kill them are human inventions. Weeds are adaptable, perhaps more adaptive than we are, and it is this characteristic that is disconcerting (Radosevich 1998). Indeed as Dekker has lamented "*the story of agriculture is indeed the story of weed interference",* not only crop protection over the past decades. In this regard, global monocultures have resulted in the appearance of global "*millennial weeds*" (Gressel, 2000) that are not being adequately controlled worldwide. However, it is common knowledge and everybody would agree that *Weed Science* has admirably risen to the challenge of scientists who hold that their work is founded on the most ethical and noble behaviour of all – feeding the world or serving humanity. Use of chemicals aligned with intensification, we usually at the expense of science fraternity define good agriculture as one that optimizes yield and maximizes profit with equitable concern for the environment. To many weed scientists like Zimdahl (2010) agriculture and indeed weed science quite often encourage widespread crop diversification and crop rotation – these sometimes contribute to the loss of small farms, and biodiversity on the farms and their fringes.

Weeds and Weed Management Practices: Prediction, Losses, Risks, and Impacts

The fallacies of modern agricultural practices give rise to weeds. It is such a pernicious aspect of food production that weeding is often the most important task (chore!) overshadows most others, most satisfying, aspects of farming. Perhaps because of this, Bishop (2004) rightly suggested that weeds should be put on the bio-security agenda at the national, regional, and international levels if weed impacts are to be effectively contained. Because of this, predictions of impacts and risks of weeds (as invasives!) on human welfare and its environment focus on two principal issues, *viz*. (i) precision in invasion predictions of plant species introduced intentionally or otherwise into an agro-ecosystem; and (ii) consequential impacts of such invasives on the environment. According to Bridges (1994), weeds impact on human endeavours. There are four sectors of economy that are directly impacted by weeds, *viz.* (i) agricultural production; (ii) forestry; (iii) non-crop land; and (iv) health. There are within the realms of economic, aesthetic, and health effects. But it is the economic impact that weeds are more worrisome to policy makers, agriculturalists and agriculturists alike. Such impacts are manifested in losses leading to the reduction in production, quality, efficiency, or functionality. Losses are sustained in every sector, and can be determined by the loss in value of productive output. Further, the costs or investments made in arresting weeds and their impacts to manage or control weeds, include inputs of labour, machinery, time, pesticides, etc. Irrespective of management tactic, costs can be ascribed to weeds. Ultimately, the total economic impact or the sum of losses and costs is the most tangible measure of the impacts that weeds have on man and his anthropogenic activities. Then there is the hidden cost to the environment due to weed infestation, namely the loss of biodiversity or environmental pollution due to non-judicious or indiscriminate use of herbicides.

To farmers, the most tangible losses due to weeds are those of crop yields and quality. Invariably, estimates of such losses are in the regions of 5% for developed economies, while in Asia Pacific, not including USA and Canada, the loss figures range from 10 to 25% (Baki, 2006b). There are also other losses such as weeds impact on man and animal health, and aesthetics, and these include direct costs health-related worker hazards and associated with medical intervention. There are notable impacts of weed poisoning and ingestion by farm animals and wildlife on reproduction, production and animal health. The persistent and indiscriminate use of herbicides for weed control may have adverse and untold damage to the end-users and environment. These include (i) impacts and risks on food safety and quality. Efforts are made to reduce pesticide resistance in target pest species, and the development of “Environmental Stewardship” efforts between relevant government agencies dealing with food production, and quality (including imported produce) and environmental safety; and (ii) impacts on soil and plant ecology, and the intricate relationships between repeated applications of herbicides and soil microbes are essentially unknown. Quite often the non-judicious use of herbicides i*mpacts on catchments and water. For example, in* US counties, no less than 46% contain ground water susceptible to contamination of herbicides, forming the bulk of agricultural chemicals used (USDA 1986, 2000). In the humid tropics, some herbicides may be delivered to surface water via groundwater through streams flow in rivers and lakes; the source of drinking water in many states. Again other risks and impacts following the indiscriminate use of herbicides include the poorly documented evidences of *herbicide run-offs on fishes and corals.* Today the increasing emergence and incidence of h*erbicide-resistant weeds pose e*cological concern worldwide. In Malaysia the high labour costs has led to the increasing dependence on herbicide-based control measures, especially in commercial crops like oil palm and rubber. It has led to parallel increase and the continuous incidence of herbicide resistant weeds in the country. Today no less than 18 weed species are resistant to commonly used herbicides such as 2,4-D, MCPA, propanil, and glyphosate. Adam *et al.,* (2009) recorded for the first time increasing resistance of *Eleusine indica* biotypes to glufosinate ammonium in Malacca and Pahang in Malaysia.

Today there are increasing evidences of gene introgressions from transgenics to weedy relatives thus impairing the benefits using transgenic resistant crops and create herbicide-resistant weeds. Gressel (2000) considered these as leading precursors to the emergence of super-weeds or millennial weeds, a case of grave concern to humanity now and in decades to come. In another circumstances, clearly, technology is not neutral. The indiscriminate use of 2,4-D and 2,4,5-T in Vietnam by the Americans in 1960s and 1970s is a disservice to humanity.

Public scholarship: linking weed science with public work

We in the weed science fraternity consider *weed scientists* as stewards of the public capacity. Although scientists in general and weed scientists in particular are largely utilitarian, it is normal for them to believe with firm conviction that their work is useful to humanity, pursued through vigorous scientific and technological progress, and this belief rests on an ethical foundation or utilitarianism of public scholarship. It is through public scholarship that enables weed scientists to pursue weed science with our highest goal, that is, commitment to serve as a civic profession that helps address major issues facing society that help create public goods, *viz.* contributions to greater commonwealth. Further, public scholarship approach is an original, creative, peer-evaluated intellectual work, fully integrated in a public-work project. It is the ultimate hope of within the weed science fraternity that bridging technology advancement generated through research via extension programmes is one way of public scholarship that ensures weed science, as a scientific and civic profession relevant to society's well-being. The paper by Zimdahl (2010) in this volume is a good example of ethics on weed science where public scholarship is an integral part of public duty that weed scientists must engage on. In the Asia Pacific, progress is underway to ensure that whatever technology advancements that are being made should be channelled to society at large. This is being so especially in the developing countries in the Asia Pacific, mostly through affirmative extension programmes with the focus to eradicate poverty through increased crop yields and quality products from agriculture.

MANAGING STRATEGY FOR WEEDS IN AGRO-ECOSYSTEMS IN THE ASIA PACIFIC

Rationale, Concepts and Ecological Considerations

The classical concept and practice of weed management is managing weed interference to minimize the effects of weed competition on the crops. Modern neoclassical, functional and economic approaches of weed management are knowledge-based, requiring knowledge-intensive management skills & inputs, *viz*. (i) Crop-weed ecology; (ii) Weed community dynamics; (iii) Economic thresholds; (iv) Production costs (including risk and ethical analysis, and costs to the environment following successive applications of herbicides); (v) Innovative ecologically based management practices; and (vi) Competitive crop cultivars, and transgenic crops.

Control Measures Against Weeds

A battery of methods is available to achieve satisfactory results in weed control. These include (i) Agro-technical and preventive methods comprising land preparation and tillage, water management, manual weeding, crop manipulation through seeding rates, planting density and allelopathy. Breeding for competitive cultivars, herbicide-resistant crop plants (HRCs) and transgenics are some of the new approaches in modern weed control. Herbicide-based weed control is a necessary package in modern agriculture, despite many environment-related problems associated with such measures. Others advocated biological control using bio-control agents or/and bio-herbicides to help alleviate the weed menace. Among them include the successful control of *Salvinia molesta* in the Sepik River in Papua New Guinea with the curculid beetles (*Cyrtobagous salviniae*). In Malaysia, the well-documented success in the control of *Cordia curassavica* by using *Schematiza cordiae* and *Eurytoma attiva* in the late 1970s in coconut plantations in Selangor. Other less remarkable success stories in the control of weeds using bio-agents include *Eichhornia crassipes* with *Neochetina bruchi, N. eichhorniae* and *Sameodes albiguttalis; Echinochloa crus-galli, E. oryzicola* and *E. picta* with *Emmalocera* sp. while the Australians were experimenting with some success in the control of *Mimosa pigra* with seed feeding bruchid beetles (*Acanthoscelides quadridentatus* and *A. puniceus*), the stem-boring moths, *Nuerostrota gunniella* and *Carmenta mimosa* and the stem-feeding beetle, *Chlamisus mimosae*.

No technology can be successful forever, especially if used as a single, “stand alone” technology. Weed scientists and extension agents world-wide including those in the Asia Pacific are advocating the integrated approaches, the Integrated Weed Management (Fig. 1) to control the weed menace. This holistic approach combines preventive measures, eradication, and control options through appropriate integration of chemical + mechanical practices + non-chemical and cultural practices + delayed crop seeding + tillage + black fallow + hand weeding + crop rotation + competitive cultivars + decision aids that directly lower selection pressure, restrict or delay the growth of resistant populations of weeds. It is expedient for farmers wherever possible to practice weed management options that facilitate increased use of conservation tillage crop production practices. The agriculture chemical companies should potentially provide opportunities for the use of more environmentally benign herbicides.

Prevention is better than cure. It is only sensible that farmers and those in the agricultural industry should be rigorous advocate and practice the concepts of good agricultural practice (GAP) in their weed management by (i) stop the introduction of noxious weed seeds or vegetative propagules; (ii) reduce the susceptibility of the ecosystem to invasive weed establishment; (iii) develop effective education and extension materials and activities; (iv) establish a knowledge-driven programme for farmers, extension agents, landowners for early detection and monitoring; (v) effective containment of neighbouring weed infestations; and (vi) strict quarantine enforcement. The extensive use of leguminous cover crops in young oil palm, rubber, and cocoa plantations in Malaysia is one of the many ways that GAP has helped to reduce chemical-based weed control measures, while

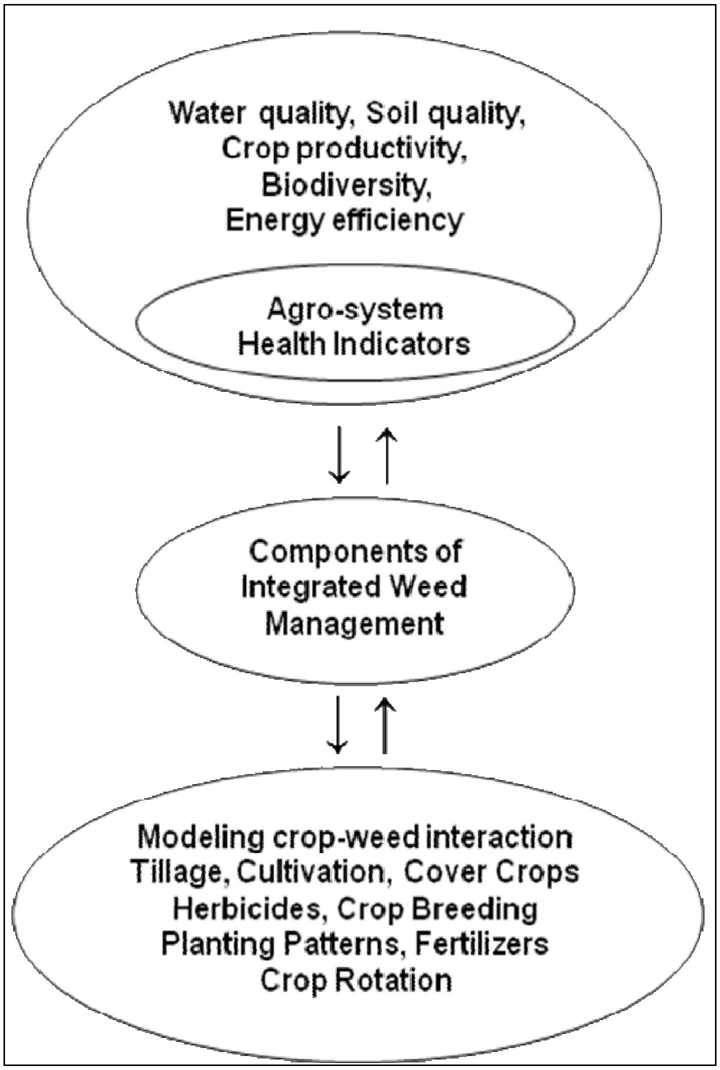

Fig. 1. The multi-faceted approaches of integrated weed management (Baki, 2006a).

enriching the soils. Another venue of the GAP is to be able to predict the rates of infestation and proliferation of weeds. This can be done by developing the expert systems for weed management. The computer-aided decision models or Expert Systems are used to assist farmers, extension agents, and weed managers in weed control decision-making for several crops. The examples include HADSS® (Herbicide Application Decision Support System) HERB®, and WebHADSS® which were designed to help farmers for weed control in cotton, peanut, corn and soybean, or WeedSOFT® which was developed to help farmers and consultants for PRE- and POST- weed control in soybean, corn, sorghum, sugar beet, and winter wheat. In this respect, the technological divide among farmers in the Asia Pacific is obvious with a sizeable number of peasantry farmers still engaged in back-breaking manual weeding in several developing countries in Asia and Latin America against their counterparts in USA, Canada, Japan, Australia and New Zealand.

RESEARCH DIRECTIONS FOR WEED SCIENCE IN THE ASIA PACIFIC

"If there is no man, there will be no woman,
If there is no weed science, there will be no agriculture,
If there is no agriculture, there will be no mankind" (Baki, 2006a).

Research Directions

I envisage that the future of weed science research will encompass the following broad aspects, *viz.* (i) Knowledge-Based and Systems Approach-Based Decision Processes; (ii) Weed Biology and Ecology; (iii) Weed Control and Management; (vi) Herbicide Resistance; (v) Issues Related to Transgenic Plants; (vi) Environmental Issues; (vii), and (viii) Potential benefits of plant species generally classified as weeds. Many of these aspects of research are knowledge-based decision support strategies (KBDSS), and systems approach-based decisions which are very dependent on database accumulated over the years. In many countries of the Asia Pacific, such approach may good on paper but will not be translated to farmers as problem-based solving technologies at the farm level. In the absent of affirmative extension systems, any information gathered in this manner remains within the realms of the academia. In any situation whether it is in the developed countries or the developing counterparts, the fundamental issue in any research adventure will be determined at least in part by resource availability vis-a-vis research plan.

In weed biology and ecology, research emphases leading to the understanding of weed response to selection pressure, weed competition and economic thresholds, and invasive alien weed remain the core activities. Then, of late, there is this new craze to understand weed genomics as fundamental tools to enhance the research capacity in herbicide resistance, issues related to transgenic plants, and potential benefits of weed species as nutraceuticals. In this endeavour, the need to explore genomics and employ molecular biology techniques to study differences between weed biotypes and analyze various traits of weeds is implicit.

Central to effective herbicide-based weed management systems is the research on herbicide efficacy enhancement. Of particular interest is area on precision agriculture or site-specific agriculture/site-specific weed management which optimizes agricultural inputs so as to match field heterogeneity in herbicide application rates. Strategically aligned to this the need to find or research into alternative weed management methods. These alternatives only suppress weeds as opposed to eliciting effective control while at the same must be efficacious and economical. Dr. Y. Fujii (*pers, comms*.) and his group at the National Institute of Agro-environmental Sciences (NIAES), Japan strongly advocated the search for new bioactive natural products, the allelochemicals as effective biochemicals to suppress weeds. Others advocate the need to develop simulation models on weed populations. Such models will require large database of weed ecology and biology characteristics. Such information can be used to continuously and systematically improve and refine weed management system simulation models. Such augmentation of information from the database will help to generate weed management tools for growers and extension agents.

Agriculture in the Asia Pacific to certain extent is laden with agrichemicals. The world's consumption of pesticides in 2000 was already in billions of US dollars, of which herbicides took the lion's share of the market (Underwood, 2000) (Fig. 2). Other than the environmental hazards posed by these herbicides, a worrisome phenomenon in chemical-based modern agriculture is the continuous emergence of herbicide resistant weeds, particularly in Canada, USA, and Australia to name a few Asia Pacific countries. Malaysia is not an exception with no less than 18 weed species showing moderate-to-strong resistance to commonly used herbicides (Baki, 2006a,b). The FAO has rated pesticide resistance as 3rd greatest problem in global agriculture, behind soil erosion and pollution. At the global scale, about 291 resistant weed biotypes in 174 species (104 dicots and 70 monocots) in over 270,000 fields were found (Heap, 2004)**.** By 2010, the number of resistant weeds exceeds 300 biotypes (Heap, 2010). With the build-up of resistant weed biotypes, I suggest the need for more extensive research on the characterization the mechanism of herbicide resistance using modern techniques; monitoring and investigating herbicide cross- and multiple resistance and fitness of resistant populations in order to assess alternate control methods, and the potential for spread of resistance; assessment on the economic impact of herbicide-resistant weeds; and of course the development of IWM strategies to ameliorate the adverse effects of resistant weeds in cropping systems. All these need well-placed manpower and research funding. Because many countries in the Asia Pacific do not have the necessary funding and man-power expertise to tackle the continuous emergence of herbicide resistant biotypes, it is only proper that respective governments in the APEC (Asian-Pacific Economic Caucus) fraternity should find ways to share the burden of solving these common problems through training and information sharing. The HIRAC organization should be strengthened further to include new members from developing countries.

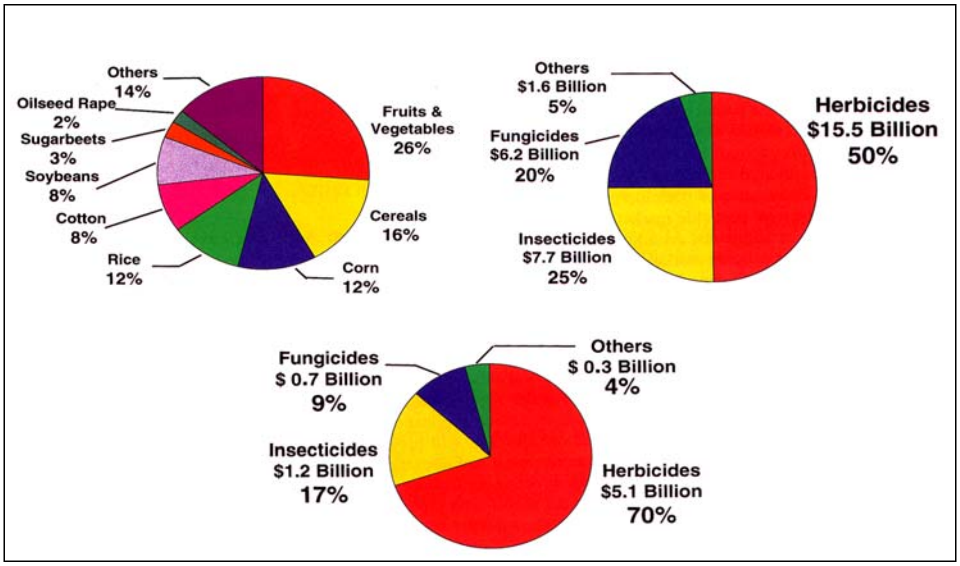

Fig. 2. Pesticides consumption at the global scale (Underwood, 2000).

One of the ways to tackle these herbicide-resistant weeds is through genetic engineering by producing herbicide-resistant crops (HRCs). Despite acceptance of these crops in many countries in the Asia Pacific, the HRCs especially the transgenics are not without controversy. There are pertinent issues related to the introduction of HRCs and transgenics. These include serious concerns on the safety of these crops not only to the environment but also to the consumers. A lot more research needs to be done before any universal acceptance of HRCs and transgenics and their produce by the consumers at large. Uncertainty is looming on the long-term agronomic and ecological effects of HRCs. Another argument against the adoption of HRCs and trangenics is that growing HRCs means a continuation of dependence on herbicide-based weed management. Further, successful introduction and adoption of HRCs will lead to considerable slowdown in the development of innovative non-chemical weed control methods. Again there are differences in opinion on the environmental quality of the herbicides for which HRCs and transgenic crops are being developed.

Proponents of HRCs and trangenics argue that these crops may hold benefits for sustainable agriculture, *viz.* (i) current herbicides may be replaced by those more environmentally-benign; (ii) may contribute to IWM by increasing the options of weed control; (iii) fit well with the goals of site-specific management because PRE would be replaced by POST treatment; (iv) promote systems for conservation tillage and mixed cropping; and (v) lower the costs of weed control. These being the case, the seed trade and the associated herbicides are being held by multinationals, many of which have invested a lot of funds for research, and thus are not likely keen to share the information and trade secrets, even pressed to do so by the governments of the day.

There are still many unanswered questions pertaining to the adoption of HRCs and transgenics. Serious in-depth non-partition research by government scientists and NGOs on HRCs and transgenics need to be done on several fronts, *viz.* (i) Analysis on the effects and potential consequences of widespread use of transgenic crops on weed population dynamics and weed ecology, and of increased weed resistance; (ii) Quantification of the effect of HRCs on the management of herbicide-resistant weeds; (iii) Determination on the potential of transgene introgression, particularly on the flow of resistance genes from transgenic crops to weeds, and (iv) Determine the socio-economic impacts of transgenic crops on the society.

A lot of weeds are reservoirs for nutra-ceuticals and the pharmaceuticals (Baki 2007, 2009). The mega-biodiversity centres like Malaysia, Indonesia, Thailand, Papua New Guinea and the Philippines are in fact natural reservoirs for the food and drug industries. Kim *et al*. (2007) compiled and edited a multi-authored book with useful information on the utilization of weeds, their relatives and resources.

Standard Operating Procedures (SOPs)

These are explicit step-by-step instructions for carrying out experimental tasks that are components of experimental plans for weed scientists. We in the weed science fraternity believe that the SOPs in weed science research will enhance data accuracy, precision, and reproducibility, thus forming part of their own statistical quality control procedures. By adopting the SOPs, weed scientists are to gain from threw advantages, *viz*. (i) facilitate document repetitive research methods; (ii) streamline the planning of experiments; (iii) facilitate concerted teamwork, supplement training, enhance communication and facilitate discussions among researchers; (iv) reference on safety, health or environmental concerns, sourcing supply checklists of equipments, chemicals, etc., assembling them completely before experimentation; (v) help maintain research continuity over time, especially in standardizing repetitive time-mediated research tasks; (vi) help coordinate research efforts and prevent procedural errors when several people contribute separately to cooperative and coordinate research projects; and (vii) ensure data reproducibility and variability are maintained consistently over time by all people contributing to team research projects.

Ethics of Weed Science Research in the Service of Humanity

It is often said that weed science is a microcosm of agriculture's "neckriddle" with many other agricultural disciplines. More importantly, weed science is in fact a microcosm of larger societal debate concerning many tools and tactics used in food production, and the consequences of current and future developments in agricultural technology. In the endeavour to provide solutions to farmers at large, weed scientists knowingly or unknowingly considers weed science as a "reductionist science". However, the catholic and cardinal issue for weed science is *technological determinism.* I believe that the traditional, empirical, and reductionist approach to weed science research will not likely to provide solutions to weed science's neckriddle. In the same vein, the long-term improvements in weed science research and application will require an intellectual convergence between traditional weed control practices and fundamental ecological theory. Such convergence will not be possible in many developing countries in the Asia Pacific due to lack of critical mass of weed scientists and researchers in weed science to achieve meaningful goals in the research endeavour. Quite often policy makers do not see the roles of weed science in the national economy well being, by providing insufficient funds for research and man-power training.

Invariably, weed science fraternities worldwide faced with philosophical and personal purgatory, thus influencing an individual's career path from early pre-tenure decisions to those faced by senior scientists on the path of retirement. Weed scientists, quite often faced pertinent questions on the ethics of research in the subject, *viz.* (i) What is the right topic for an individual, public sector weed scientist to choose for research? (ii) Is there an inherently unethical research topic? and (iii) Do public sector weed scientists have a moral obligation to pursue the best research topic they are capable of? Then there is this ethical foundation in inherent values and choice of topic, taking into consideration *inter-alia*, the following aspects, *viz*. (i) respect and credibility; (ii) making a contribution to the fraternity; (iii) funding and career advancement, and (iv) explicit and implicit employers' expectations, which at times may be in conflict with our values. From another perspective, tenure, peer pressure, dogma, and at times, current hot topic mentality, are in conflicts thus representing likely constraints in our choice in research priority.

Another serious problem facing weed scientists is confronting complacency. Every public sector researcher is responsible to God, employers, taxpayers, and themselves for the choices made in their research endeavour. It is often alleged that weed scientists lack diversity and unimaginative in our choice of research topics, and as generalists – tackling many research problems superficially, research programmes lacking focus and depths, and at times resist specialization. Further the herbicide industry dominates the research agenda focusing on herbicide efficacy, and less on agricultural sustainability and environmental safety.

FUTURE TRENDS AND CHALLENGES IN THE ASIA PACIFIC

"No less than 20% of the world's population, or 840 million people, are still hungry and in abject poverty. The greatest challenge to agriculture (and weed science) is to feed not only the burgeoning population but also the poor and the hapless" (Solh and Pingali, 2004).

The world's populace in general and Asia Pacific in particular are concerned with and facing challenges in three fronts (i) Food Scarcity and Food Security (FSFS), (ii) Agricultural Sustainability, and (iii) Environmental Health. These general concerns on FSFS which is synonymous with 21st century agriculture, lingers constantly in developing economies to feed the growing populace. The absorbing question on this issue of FSFS in many countries of the Third World in the Asia Pacific, is there a choice for the hungry and destitute? Antithesis to these issues would be (i) Is it not the social obligation of the government of the day to ensure food security for its populace so that hunger and famine will no longer haunt mankind? and (ii) Are not the goals of agriculture (akin to the goals of weed science) towards profitable production, sustainable production, environmentally-safe production, satisfaction of human needs, compatibility with just social order akin to the challenge of FSFS especially in the less developed countries of the Asia Pacific?

Another worrisome trend of world's agriculture is the tide of globalization and increased international trade in the 21st century which leads to breakdown of bio-geographical barriers and higher plateaus of species invasions, coupled with intentional, callous and clandestine introductions of plant (weeds!), many of them are invasive in nature, and these ultimately threaten community structure, and species interactions of native species. In this regard, the Global Invasive Species Program (GISP), engaging scientists, policy makers, legal experts , industry and government in serious deliberations under 11 elements on building a comprehensive approach needed for dealing with invasive species. These elements deal with synthesizing our current knowledge on invasives at the global scale and in the Asia Pacific where the need arise.

Future initiatives in weed science hinge on the ability to provide multi-dimensional approach in weed control technologies against not only the existing weed species but also the new waves of invasions of alien and *super* or *millennial weed species* due to anthropogenic activities and trade and the expected wider adoption of HRCs and transgenics by farmers even in the less developed countries in the Asia Pacific. Such initiatives are taken towards a socially permissible, environmentally sound, economically feasible, productive and sustainable agricultural system. In this respect, and among other things weed scientists playing key roles in the development and field evaluation of transgenic HRCs, and continued use of herbicides and adoption of HRCs comes the inevitable ecological risks to the environment. If such scenarios were to materialize, stringent ecological risk assessment of herbicide resistant crops and screening for increased incidence of herbicide-resistant weeds are to be in place.

With modernization comes the need to produce quality foods that are consumer-driven in increasingly affluent societies. At times, advances in biotechnology with tremendous shake-up in the agrochemical industry where the worrisome trends of a few dominant multinationals controlling significant shares of advanced germplasm and HRCs for the world's major crops. These multinationals with cutting-edge technology in agricultural biotechnology are antithesis to the development inspired in resource-poor developing economies of the Asia Pacific. With this backdrop on the advances in biotechnology, the weed science fraternity is facing major issues and challenges inharnessing cooperation and political will among policy makers and scientists through The Scientific Committee on Problems of the Environment (SCOPE) in collaboration with the United Nations Environment Programme) (UNEP), the International Union for the Conservation of Nature (IUCN) to ensure technology sharing for the benefits of mankind.

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