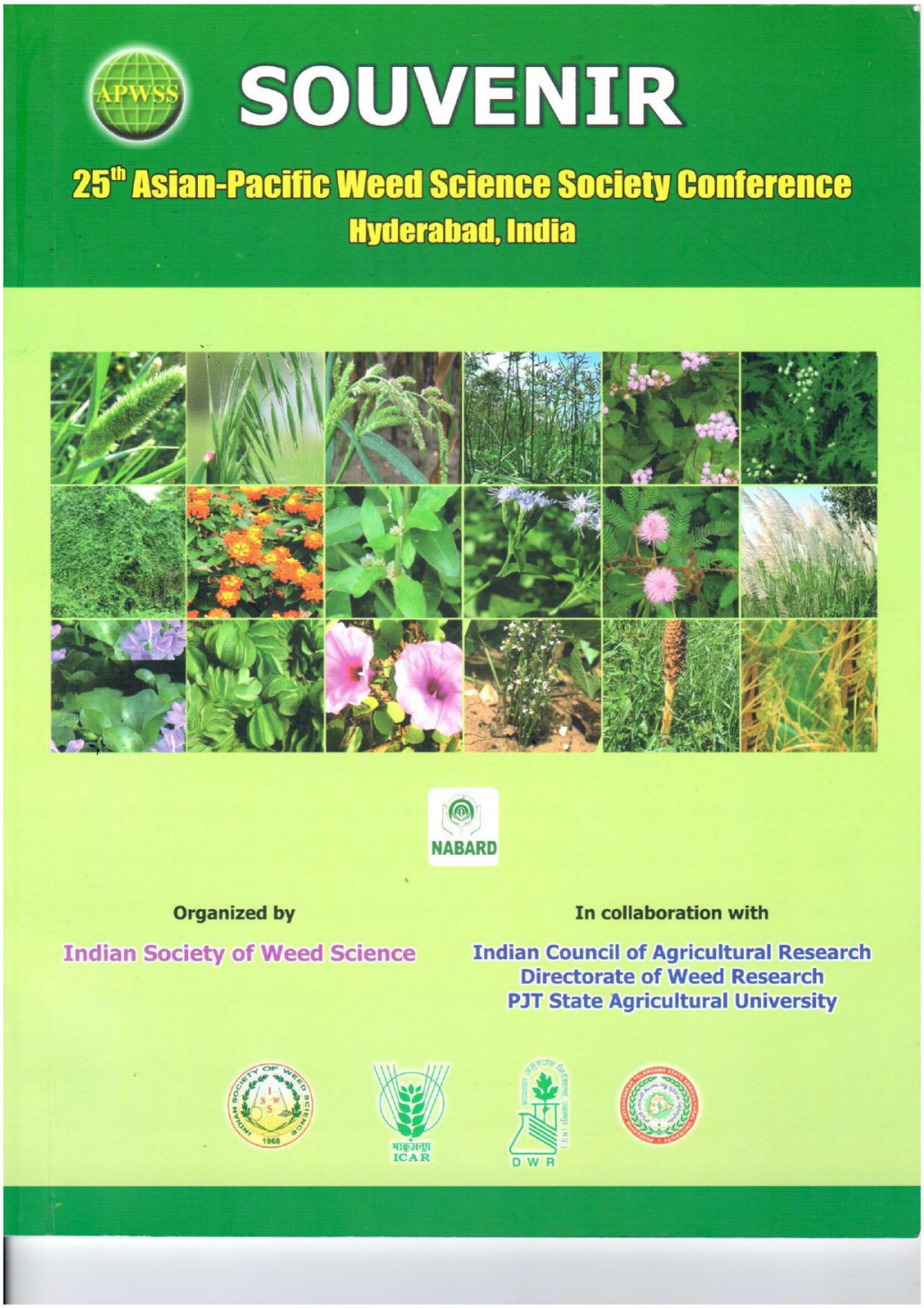
A.N. Rao and S.P. Wani. 2015. Trends in managing weeds of rice in Asian-Pacific region. pp.1-3. In: Souvenir 2015. 25th Asian-Pacific Weed Science Society Conference, Indian Society of Weed Science, Jabalpur, India



Trends in managing weeds of rice in Asian-Pacific region

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Rice is the main staple in the Asia and the Pacific (AP) region. It is often said that in AP region "Rice is Life" and rice availability is equated with food security. It is estimated that demand for food and non-food commodities is likely to increase by at least 60% globally between 2010 and 2050, with many developing countries having to double their food production, which is possible only by the increased production of major staple crop, rice. Future rice production will be limited on a global scale by the availability of land, water, and energy for which weeds compete with rice. Weeds associated with rice vary with the country, method of rice establishment, the rice cultivar grown, management practices used and the environment. Publications enlisting predominant weeds associated with rice in each of the country of AP region are available. The extent of yield losses caused by weeds depends on the weed species associated with rice, their predominance and associated environmental factors. Estimates at global level indicate that weeds account for 48.2% of potential losses and 27.3% of actual losses caused by all pests together. Hence weed management will play a critical role in realizing needed increase in rice production in AP region. Integrated weed management practices are needed for achieving increase in productivity and production of rice while addressing the environmental and other problems created by current and past weed management practices.

Manual weeding, alone or in combination with other methods, is still the most predominant method of weed removal in many countries in the AP region. However, it is not only tedious, time-consuming and inefficient but is increasingly becoming uneconomical as well. Wage rates for farm workers in South East Asia have steadily increased; the average wage rate today is 5-10 times greater than what was prevalent in the 1970s. For example: in India the wages were less than US $0.5 in 1970s, which currently range from US $ 4-5 per person per day. In other words, one time hand weeding of one hectare rice which used to cost us $10, costs now a minimum of US $80. Poverty alleviation programs introduced in some countries to promote inclusive growth in economy have also contributed to the scarcity of labor for farm work. Use of draught animals for intercultural operations is also coming down even though in upland dry-seeded rice of India, inter cultivation using blade harrow is common method of managing weeds in combination with hand weeding. Cono weeders are also used in row wet-seeded and transplanted rice in India and other developing countries by a few farmers. Power tillers are being introduced under programs such as Bhoo Samrudhi in Karnataka state of India.

As farm wages have increased due to economic growth and government policies in some countries in AP region, herbicides have increasingly been substituted for hand weeding. Between 100-200% increases in the current labor price are expected within 5-10 years. Farmers are left with little choice but to reduce labor and production costs, particularly for the most labor-intensive tasks, such as manual weeding. Studies by scientists in Bangladesh revealed that pre-emergence herbicides in rice are 38.46% cheaper than one hand weeding and

the herbicide application gave 116% higher net income than hand weeding due to increased yield and lower cost of weeding. Thus, the use of herbicide has increased over years in AP regions developing countries including China and India. In China, the area treated with herbicides has increased from less than one million hectares (mha) in the early 1970s to more than 60 mha in 2000. Rice accounted for 17% of total herbicides (6705 metric tonnes) used in India in 2010. In Malaysia, weed management is herbicide-based and about US $ 4.10 million is spent annually on herbicides for rice alone, and this amounts to approximately 7% of the total expenditure on herbicides as per reports in 2004, which might have increased further by now. In Philippines, 96-98% of rice farmers use herbicides with the majority of farmers supplementing herbicide application with hand weeding. In Pakistan, about 20% area in rice is treated with herbicides. In Korea, the rice area treated with herbicides was 27% in 1971, 65% in 1977 and currently entire area is treated with herbicides. The trend of increasing use of herbicides in rice production has been observed in Vietnam. There are about 37 compounds or proprietary mixtures formulated in 79 commercial products available for use in Vietnam. Vietnam used 5,000 tonnes of herbicides (19% of total pesticides) costing US $18 million, with rice herbicides contributing 89% in 2002. In Nepal, 91% of rice farmers were reported practicing manual weeding and only about 2% reported to have used butachlor.

Herbicides have been and will continue to be the major tool for managing weeds of rice in AP region. However, continuous use of herbicides have resulted in the incidences of resistant weeds, which is more in developed countries like Australia, where herbicides have been in use for long. Among crops, wheat and rice have more herbicide resistant weeds than maize. In developing countries of AP region also, the shift in method of rice establishment to direct-seeding, increased herbicide use and continuous use of similar herbicides is resulting in weeds resistance in rice. For preventing the development of herbicide resistance in weeds, the best management practices (BMPs) were suggested by Weed Science Society of America (WSSA) and these may also be popularized among the rice farming community of AP region. WSSA (Thanks to WSSA) says that effective herbicide-resistance management programs must consider all available options for effective weed control and use the following BMPs:

- Understand the biology of the weeds present
- Use a diversified approach toward weed management focused on preventing weed seed production and reducing the number of weed seeds in the soil seed-bank
- Plant into weed-free fields and then keep fields as weed free as possible
- Plant weed-free crop seed
- Scout fields routinely
- Use multiple herbicide mechanisms of action that are effective against the most troublesome weeds or those most prone to herbicide resistance
- Apply the labeled herbicide rate at recommended growth stage of weeds
- Emphasize cultural practices that suppress weeds by using competitive cultivars of crops
- Use mechanical and biological management practices where appropriate
- Prevent field-to-field and within-field movement of weed seeds or vegetative propagules
- Manage weed seeds at harvest and post-harvest to prevent a buildup of the weed seed-bank
- Prevent an influx of weeds into the field by managing field borders

In addition to recommending specific BMPs, the WSSA also endorses the following:

- Reduce the weed seed-bank through diversified programs that minimize weed seed production
- Implement an herbicide mechanism of action labeling system for all herbicide products, and conduct an awareness campaign
- Communicate that discovery of new effective herbicide mechanisms of action is rare and that the existing herbicide resource is exhaustible
- Demonstrate the benefits and costs of proactive, diversified weed management systems for the mitigation of herbicide-resistant weeds
- Foster the development of incentives by government agencies and industry that conserve critical herbicide mechanisms of action as a means to encourage adoption of best practices
- Promote the application of full-labeled rates at the appropriate weed and crop growth stage. When tank mixtures are employed to control the range of weeds present in a field, each product should be used at the specified labeled rate appropriate for the weeds present
- Identify and promote individual BMP that fit specific farming segments with the greatest potential impact
- Engage the public and private sectors in the promotion of BMPs, including those concerning appropriate herbicide use
- Direct federal, state and industry funding to research addressing the substantial knowledge gaps in best management practices for herbicide resistance and to support cooperative extension services as vital agents in education for resistance management

The BMPs that are of relevance for each of the country in the AP region may be effectively used for managing weeds of rice and rice-based cropping systems.

Weedy rice is becoming a threat in rice and especially in direct-seeded rice fields of AP region and it needs special attention by researchers to prevent its spread and effectively manage, in each of the country of AP region. Clearfield rice – an imidazolinone (IMI) resistant rice derived from conventional breeding technique, has been in cultivation in Malaysia mainly for managing weedy rice. It is under testing stage in Vietnam. The possible evolution of resistance to ALS-inhibitor herbicides in weedy rice and the risk of weedy rice acquiring resistance to herbicides following introgression of resistant gene from the HT rice are the major concerns that need to be addressed adequately. Educating rice farmers is essential prior to the release and popularization of genetically/conventionally modified rice varieties tolerant to herbicides.

Climate change is of concern to rice farming community, as loss in yield so far in rice was estimated to be around 17% due to changing climate. The impact of climate change on weeds, rice-weed competition and weed management in rice of AP region is yet to be understood clearly. Future research efforts must be made to evolve and popularize climate resilient strategies by integrating herbicides and non-chemical methods for effective, economical and eco-efficient weed management in rice and rice-based cropping systems.