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Taxonomic diversity, distribution pattern and management implications of weed flora in rice fields of Kashmir Valley

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ABSTRACT

Invasion by problematic weed species is one of the major contributors in the loss of potential yield in rice cultivation. Therefore, weed flora associated with rice crop in Kashmir Valley was investigated. Based on extensive field surveys carried out during 2010-2013, the present study revealed that 40 plant species were growing as weeds in rice fields of Kashmir Valley, which belonged to 27 genera in 19 families. The actual weeds of rice (40 species) and the weeds (58 species) growing along raised bunds and in between undulated lands of rice fields were recorded. Six species have been reported for the first time as rice weeds. For each weed species, crucial data on growth form, life span, flowering and fruiting months, breeding and dispersal mechanisms were obtained. Weed species growing commonly in the rice fields of Kashmir Valley, as well as those growing rarely were identified. Though weed species were distributed throughout the region, the overall taxonomic diversity of weed flora in rice fields were drastically declined from North to South in Kashmir Valley. Based on the data obtained on diversity and distribution of weed flora, the paper also discusses long-term weed management in the rice fields of Kashmir Valley.

Key words: Distribution**,** Diversity, Management, Rice, Weed

Rice is an important cereal crop providing food for more than half of world's human population (Mulungu *et al*. 2011). It is a staple food to feed more than 3 billion people and to provide 50-80% daily calorie intake (Choudhary *et al*. 2011, Juraimi *et al*. 2011). In India, rice is the second most important crop after wheat, and the country is world's second largest producer of rice after China (Savary *et al*. 2005). Being the staple food, it plays a significant role in the economy of India and hence occupies a central position in national agricultural policy and food security (Dangwal *et al*. 2011). The average per hectare yield of rice in India is less as compared to China due to many factors, such as shortage and high cost of labour, lack of irrigation facilities, quality of germplasm, agricultural output and ecological conditions *etc*. but the problem of weed invasion is the major contributor in the loss of potential production. Out of total losses incurred to rice due to various biotic stressors, weeds are known to account for one-third (Rao and Nagamani 2007). Uncontrolled infestation of weeds in rice fields reduces the grain yield by 75.8, 70.6 and 62.6% in dry seeded rice, wet seeded rice and transplanted rice, respectively (Singh *et al*. 2005).

In the Indian Himalayan state of Jammu and Kashmir (J & K), particularly in Kashmir Valley, rice is regarded to be more than just the staple food. A relatively small area of about 0.27 million hectares of land are under rice cultivation in J & K and it plays a prominent role in the state's economy. In Kashmir Valley, 1,43,936 hectares of land is under rice cultivation and total rice production is 3,18,65 tons which does not cater to the local demand of rice in the Valley and thus the annual deficit in rice is 30-35%. Being an important staple food in the Kashmir Valley, the present study was undertaken to identify the current status of problematic weeds in rice fields across the Kashmir Valley, with an emphasis on taxonomic diversity and distribution pattern, which in turn, has wide management implications.

MATERIALS AND METHODS

Field surveys were conducted across the Kashmir Valley to identify the major problematic weed species in rice fields during 2010-2013. The Valley is situated in northern fringe of the Indian sub-continent between 33°22' and 34°50' N latitudes and 73°55'and 73°33' E longitudes covering an area of about 16,000 sq. km (Fig. 1). Three sites from each district of the Valley were selected. Field trips were conducted twice a month in each site for collection of weed species. During these trips, informal interviews were conducted with the farmers and agriculturalists at each site about the seasonal occurrence of weed species and important details about flowering and

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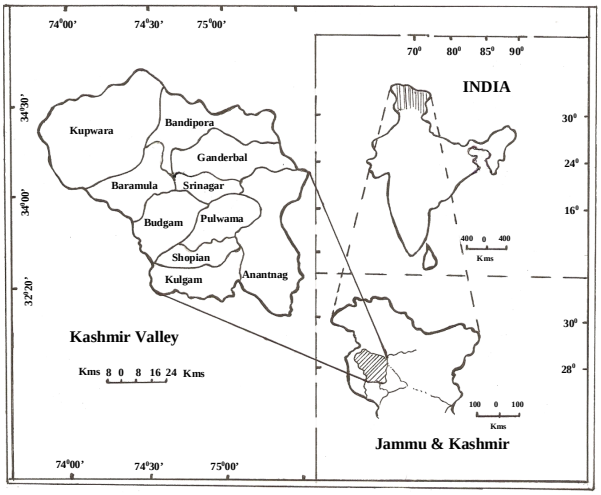

Fig. 1. Map showing the study area

fruiting periods of weed species were recorded. The collected weed plant specimens were pressed, dried, preserved and properly identified with the help of available literature (Hooker 1894, Stewart 1972, Cook 1995). The properly processed herbarium specimen of each species was deposited at Kashmir University Herbarium (KASH).

RESULTS AND DISCUSSION

During study period, 40 weed species were recorded from various rice fields across the Kashmir Valley during May to September. The weed species which grew commonly in the rice fields, their scientific name, family, growth form, life span, flowering and fruiting period is given in Table 1. The weed species which rarely grew in rice fields are presented in Table 2. While the weeds such as *Echinochloa crusgalli*, *Aeschynomene indica*, *Oenothera* sp. and *Persicaria hydropiper* sprout and grew along with the rice seedlings in the seed beds; others such as *Ranunculus trichophyllus*, *Marsilea quardifolia*, *Potamogeton nodosus* and *Persicaria hydropiper etc*. grew with rice seedlings at the time of transplantation in the prepared fields. In these weed species, both sexual and vegetative mode of reproduction are operative for their proliferation. The weed species propagated by means of different types of vegetative propagules: fragmentation (*e.g., Azolla cristata, Salvinia natans, Lemna gibba, Lemna minor, Spirodela polyrrhiza*); tubers (*e.g. Marsilea quardifolia, Sagittaria sagitifolia*); stolons (*e.g. Ranunculus trichophyllus, Utricularia aurea*); subterranean turions (e.g. *Potamogeton nodosus*). Besides, in many species, rhizomes were also the means of vegetative propagation.

During the present investigation, it was observed that the diversity of weed species in the rice fields showed a noticeable decreasing trend from north to south of the Kashmir Valley (Fig. 2). Free floating species (*e.g., Azolla cristata, Salvinia*

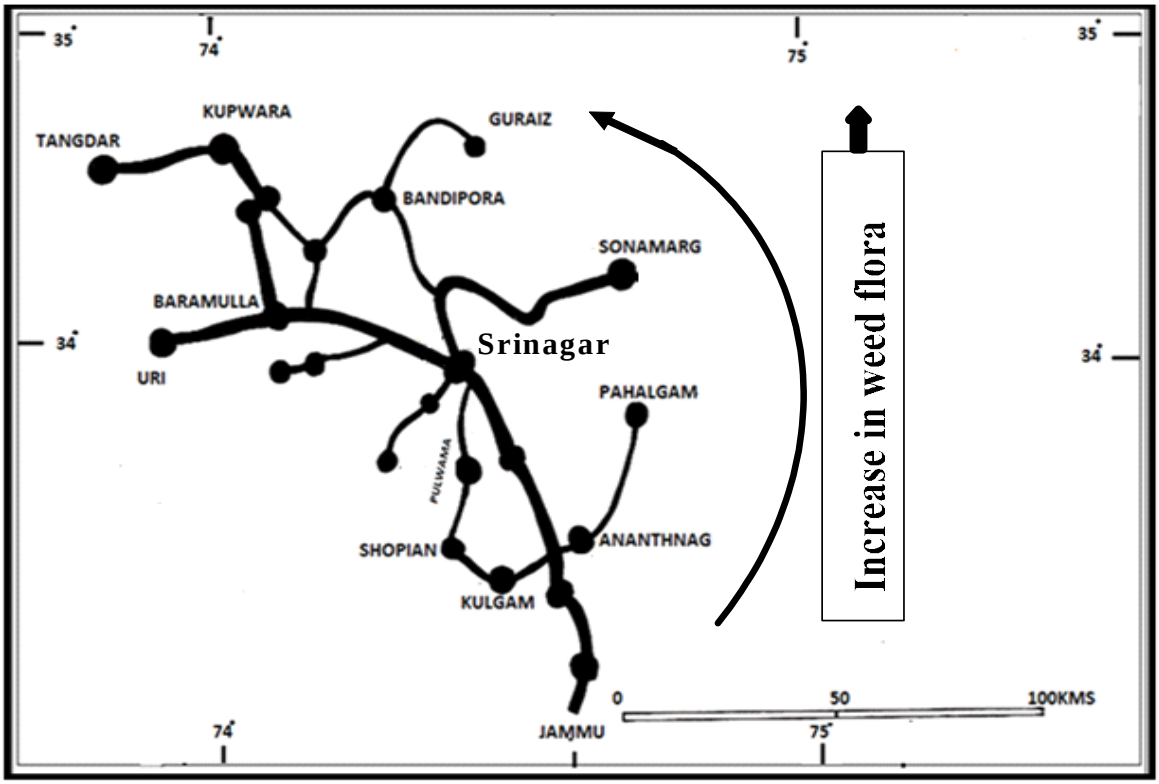

Fig. 2. Distribution pattern of weed flora showing an increasing trend from south to north in Kashmir Valley

Table 1. Weed species growing commonly in the rice fields of Kashmir Valley

Taxon	Synonym	Family	Growth form	Life span	Period of flowering/spore formation	Fruiting period
Azolla cristata Kaulf	-	Azollaceae	Free floating	Mostly annual, sometimes perennial	July-September	-
Salvinia natans L.	-	Salviniaceae	Free floating	Perennial	#July-September	-
Lemna gibba L.	-	Lemnaceae	Free floating	Perennial	July-August	Not found
Lemna minor L.	-	Lemnaceae	Free floating	Perennial	July-August	Not found
Spirodela polyrrhiza (L.) Schleid.	*Lemna polyrrhiza* L.	Lemnaceae	Free floating	Perennial	July-August	Not found
Ranunculus trichophyllus Charix	*Batrachium trichophyllum* (Chaix) Bosche	Ranunculaceae	Rooted submerged	Perennial	Jun-August	July-September
Najas oguraensis Miki	*Cauliniao guraensis* (Miki) Nakai.	Najadaceae	Rooted submerged	Annual	July-August	July-September
Marsilea polycarpa Hook. and Grev	*Marsilea quardifolia* L.	Marsilaceae	Rooted floating	Perennial	#June-July	-
Utricularia aurea Loureiro	*Utricularia confervifolia* Jackson ex D. Don	Lentibulariaceae	Rooted floating	Mostly perennial, sometimes annual	June-August	July-September
Potamogeton nodosus Pioret.	-	Potamogetonaceae	Rooted floating	Perennial	July-August	August-September
Persicaria hydropiper (L.) Delarbre	*Polygonum hydropiper* L.	Polygonaceae	Rooted emergent	Perennial	July-September	August-October
Sagittaria sagittifolia L. (sea)	*Sagittaria trifolia* Linn.	Alismataceae	Rooted emergent	Perennial	July-August	July-September
Aeschynomene indica L.	-	Fabaceae	Rooted emergent	Mostly perennial, sometimes annual	June-August	August-October
Echinochloa crusgalli (L.) Beauv.	-	Poaceae	Rooted emergent	Annual	June-September	July-October

*First reports as rice weed; #: Period of flowering

natans, Utricularia aurea and species of *Lemna*) were absent in the rice fields of South Kashmir (districts of Anantnag, Pulwama, Shopian, Kulgam) and also in Budgam district of central Kashmir, however, these species grew abundantly in the rice fields of district Srinagar and North Kashmir districts of Ganderbal, Bandipora and Baramulla. It was also found that diversity of weed species in rice fields again declined towards Kupwara district of North Kashmir. The species, which grew throughout rice fields of Kashmir Valley include: *Ranunculus trichophyllus, Marsilea polycarpa, Potamogeton nodosus, Persicaria hydropiper, Aeschynomene indica* and *Echinochloa crusgalli.*

During the present study, 40 plant species growing as weeds in rice fields of Kashmir Valley were recorded. These species belonged to 27 genera in 19 families; of the latter, 11 belonged to dicotyledons, 7 to monocotyledons and 3 to pteridophytes. With regard to growth-forms, 5 were free floating, 3 rooted submerged, 4 rooted floating and 29 rooted emergent and all the rooted emergent species grew in marshy semi-aquatic habitats. The sedges (Cyperaceae) constituted 14 species, waterwort (Elatinaceae) and loosestrife (Lythraceae) with 3 species each and grasses (Poaceae) with 2 species. The perennials constitutee 58% and annuals 42% of the total weed species of rice fields.

Moody (1989) reported 1405 weed species from the rice fields of other parts of the India. Of these, 92 species were recorded during the present study from Kashmir Himalaya. The present study revealed that among these 92 weed species, only 36 species are actually growing as weeds in the rice fields (Table 1 and 2) and the remaining weed species (58 species) are growing in the undulated lands/or on the raised bunds between the rice fields, hence these species do not compete with rice with respect to the available resources. During the present study, 6 weed species (*Azolla cristata, Carex dimorpholepsis, C. schlagintweitiana, Elatine ambigua, Lemna gibba* and *Najas oguraensis*) have been reported for the first time from rice fields of India.

Distribution pattern

The study also revealed that diversity of weed species in the rice fields of Kashmir Valley declined from North to South and mostly the free floating species were noticeably absent in the rice fields of South Kashmir. The major dispersal mechanisms of weed species were by water, birds, soil adhering to farm machinery and contaminants of cultivated rice seed stocks (Barrett 1980). During the present investigation, it was observed that the species which produce seeds are present in rice fields of whole Kashmir Valley.

Table 2. Weed species growing rarely in the rice fields of Kashmir

Taxon	Synonym	Family	Growth form	Life span	Flowering period	Fruiting period
Carex fedia Nees	*Carex wallichiana* Presc	Cyperaceae	Rooted emergent	Perennial	May-June	July
**Carex dimorpholepis* Steud.	*Carex cernua* Boott	Cyperaceae	Rooted emergent	Perennial	June	July
**Carex schlagintweitiana* Boeck.	*Carex setigera* D. Don	Cyperaceae	Rooted emergent	Perennial	June	July
Cyperus compressus L.	-	Cyperaceae	Rooted emergent	Annual	July-August	August-September
*Cyperus distans*L.	*Cyperus elatus* Rottboll	Cyperaceae	Rooted emergent	Perennial	July-August	August-September
Cyperus elatus L.	-	Cyperaceae	Rooted emergent	Perennial	July-August	August-September
Cyperus iria L.	-	Cyperaceae	Rooted emergent	Mostly annual, sometimes perennial	July-September	September October
Cyperus pangorei Rottboll		Cyperaceae	Rooted emergent	Perennial	August-September	September October
Cyperus pilosus Vahl	*Cyperus obliquus* Nees	Cyperaceae	Rooted emergent	Perennial	August-September	September October
Cyperus pygmaeus Rottboll	*C. michelianus* (L.) Del.	Cyperaceae	Rooted emergent	Annual	July-August	September
Eleocharis atropurpurea (Retz.) J.Presl & C.Presl	*Scirpus atropurpureus* Retzius	Cyperaceae	Rooted emergent	Annual	July-August	September
Fimbristylis dichotoma (L.) Vahl	*Scirpus dichotomus* L.	Cyperaceae	Rooted emergent	Mostly perennial, sometimes annual	June-July	August
*Fimbristylis dichotoma*ssp. *podocarpa* (Nees) T. Koyama	-	Cyperaceae	Rooted emergent	Annual	June-July	August
Fimbristylis littoralis Gaudichaud	-	Cyperaceae	Rooted emergent	Annual, sometimes biennial	June-July	August-September
Bergia ammannioids Roxb.ex Roth.	-	Elatinaceae	Rooted emergent	Annual	June-July	August
**Elatine ambigua* Wright	-	Elatinaceae	Rooted emergent	Annual	June-July	August
Elatine triandra Svhkuhr	-	Elatinaceae	Rooted emergent	Annual	June-July	August
Ammannia auriculata Wild.	*Ammannia arenaria* (Kunth) Koehne	Lythraceae	Rooted emergent	Mostly annual, sometimes perennial	June-July	August
Rotala densiflora (Roth) Koehne		Lythraceae	Rooted emergent	Annual	June-July	August
Rotala indica (Roth) Koehne		Lythraceae	Rooted emergent	Mostly annual, sometimes perennial	June-July	August
Echinochloa colona (L.) Link	*Panicum colonum* L.	Poaceae	Rooted emergent	Annual	July-August	September
Dopatrium junceum (Roxb.) Buch.-Ham.	*Gratiola juncea* Roxburgh	Scrophulariaceae	Rooted emergent	Annual	July-August	September
Hydrilla verticillata (L.f.) Royle	-	Hydrocharitaceae	Rooted submerged	Perennial	June-July	August - September
Hydrocharis dubia (BI.) Backer	-	Hydrocharitaceae	Rooted floating	Perennial	August - September	October
Juncus articulatus L.	-	Juncaceae	Rooted emergent	Perennial	June-July	August
Lathyrus aphaca L.		Fabaceae	Rooted emergent	Perennial	June-July	August

*First reports as rice weed

Rice fields are favorite habitat for birds because of abundant presence of food in the form of seeds and they are important in local as well as long-distance dispersal of aquatic plants and undoubtedly play an important role in the establishment of new genotypes in existing populations and dispersion of populations into new regions (Harwell and Orth 2002). However, the species which reproduce by vegetative means only are less widely distributed and are found in the rice fields of those areas which are

connected to main water bodies particularly with the Valley lakes. The flow of water from one location (from the Valley lakes in central Kashmir to rice fields in North) to another particularly downstream movement determines the distribution of these weeds. Hydrochory, *i.e*. dispersal by water, is one of the major dispersal mechanisms for plants along river corridor (Johansson and Nilsson 1993).

Management implications

Most of these weed species flower during June-September and fruiting starts from August-September (Table 1). Majority of the vegetative propagules are produced during August-September. The knowledge of life history traits can be utilized to identify the weak points in the plant's life cycle, and exploit them for long-term management (Madsen 1993); for instance, most of the weeds documented produce fruits and vegetative propagules during August-September. Therefore, removal of these weeds physically or by using herbicides in the month of July would be a cost-effective control to check their prolific growth and spread.

The various modes of vegetative propagation operative in these species makes them serious weeds and difficult to control. Therefore, knowledge about timing of formation and germination of these propagules is critical in their long-term management. For effective management of weed species such as *Echinochloa crusgalli, Aeschynomene indica* and *Persicaria hydropiper*, seeds of these species should be separated from the seeds of rice by employing different separation methods *e.g*. winnowing, sieving, floating method *etc*. Moreover, deep ploughing of seed beds and fields before transplantation could also prove helpful in controlling the spread of these weeds as it exposes the different vegetative propagules like rhizomes, stolons, turions *etc*. to direct sunlight that results in drying and ultimately death and decay of these propagules.

Another critical factor in weed management is the correct taxonomic identification of the problematic weed species, which is crucial in the removal of seedlings of target species at the time of transplantation. For instance, seedlings of *Oryza sativa* and *Echinochloa crusgalli* are very much similar and difficult to segregate at vegetative phase. However, these two species can be separated on the basis of the lower portion of underground part of these two species. The culm and roots of *Echinochloa crusgalli* are white while in *Oryza sativa* the lower portion of stem and roots are brown in colour. Cutting of weed species particularly the sedges and grasses at the time of flowering stage (best stage for correct identification) is another measure for effective management of these species.

To summarize, the present study revealed 40 plant species to grow as weeds in rice fields across the Kashmir Valley. Diversity of these weed species is more in rice fields of northern part as compared to southern part of the Valley. Information regarding the correct taxonomic identification, modes of reproduction and life history pattern are important for long-term management of these weeds.

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