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Conserving Floral and Faunal Diversity of Rice Paddies

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Rice paddies have complex trophic food webs of flora and fauna. Integrated biodiversity management of flowering forbs can help conserve the beneficial insects of rice ecosystem, in turn enhancing natural biological control of pests. A concept of habitat management through ecological engineering has been developed at the ICAR-Indian Institute of Rice Research, tested, and validated in farmers' fields over several seasons of crop. The strategies are low cost, easy to adopt, ecological sound and environmentally friendly, while providing farmers with monetary returns and nutritional benefits. One of the techniques advocated, is increasing floral diversity. Floral diversity can be maintained by conserving commonly occurring flowering forbs in rice fields or by growing a crop plant that provides monetary and nutritional benefits. Flowering plants on rice bunds had significant impact on biodiversity of parasitoids such as *Anagrus*, *Oligosita* and others. Field studies through baiting and laboratory studies for longevity indicated enhanced parasitization rates and six to ten times increase in longevity of parasitoids. Significant differences were observed in parasitism of hopper eggs in plots with different crop borders in comparison to plots without flower borders (F= 4.91; df 7; p <0.01).

Introduction

Rice is the staple food crop of 3.5 billion people around the world, mostly from Asia. Rice paddies are unique eco-systems having aquatic, benthic and terrestrial niches that harbour a complexity of flora and fauna which interact with each other. An approach for "Integrated biodiversity management" was proposed by Kiritani (2000). Habitat management through ecological engineering is an ecofriendly technique that is gaining popularity among biocontrol advocates. Though the term was coined by Odum (1971) in the broader sense, it was adapted to pest management in crops (Gurr *et al*., 2004). It encompasses habitat manipulation through cultural methods to enhance biological control (Gurr *et al*., 2004) and help harness the existing biodiversity in agro-ecosystems for sustainable pest management. Despite the potential in enhancing the effectiveness of natural enemies of rice pests by manipulating nearby habitat (Gurr *et al*., 2011), efforts to do so have been limited. One way to conserve natural enemies is through increasing the diversity and density of nectar bearing flowering plants in the rice fields. Such plants may provide nectar and pollen, important alternate foods for many parasitoids and predators by increasing their longevity and fecundity (Landis *et al*., 2000). Specific natural enemies whose activities and impact are increased from the presence of specific flowering plants can be identified through research on nectar and pollen qualities. Flower species that meet the needs of natural enemies, while minimising support to pests should be selected (Gurr *et al*., 2011).

We studied the biodiversity of flowering forbs surrounding rice fields and their potential for utilization in habitat management. A total of eighty plant species were observed belonging to 29 families viz., Acanthaceae, Aizoaceae, Amaranthaceae, Apiaceae. Apocynaceae. Asteraceae, Brassicaceae. Capparaceae, Commelinaceae, Convolvulaceae, Euphorbiaceae, Fabaceae, Juncaceae, Lamiaceae, Lythraceae, Malvacea, Menispermaceae, Nyctaginaceae, Oxalidaceae, Plantaginaceae, Poaceae, Portulacaceae, Primulaceae, Solanaceae, Tiliaceae. Verbenaceae, Verbenaceae, Verbenaceae and Zygophyllaceae. Of these the most amenable for habitat management belonged to the two families Fabaceae and Asteraceae (Table 1).

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Table 1. Candidate plant species for *in situ* conservation in rice paddies

S.No.	Plant species	Family	Suitable for habitat management	Benefits	Natural enemies
1	*Ageratum conozoides* L.	Asteraceae	Y	Pollen, nectar	coccinellids, parasitoid wasps, spiders
2	*Parthenium hysterophorus* L.	Asteraceae	N	Pollen, nectar	coccinellids
3	*Spheranthus indicus* Linn.	Asteraceae	N	Pollen, nectar	coccinellids, mirids
4	*Acmella uliginosa* (Sw.) Cass.	Asteraceae	Y	Pollen, nectar	coccinellids, mirids, spiders
5	*Eclipta prostrata* L.	Asteraceae	Y	Pollen, nectar	coccinellids, parasitoid wasps, spiders
6	*Tridax procumbens* L.	Asteraceae	Y	Pollen, nectar, alternate prey	coccinellids, parasitoid wasps
7	*Caesulia axillarisi* Roxb.	Asteraceae	N	Pollen, nectar	spiders
8	*Vigna trilobata* (L.) Verdc.	Fabaceae	Y	Nectar, alternate prey, honey dew	coccinellids, parasitoid wasps, spiders
9	*Macroptilium atropurpureum* (DC.) Urb.	Fabaceae	N	Nectar, honey dew, alternate prey	coccinellids, parasitoid wasps, spiders
10	*Melilotus alba* Medik.	Fabaceae	Y	Nectar, alternate prey, honey dew	coccinellids, parasitoid wasps, spiders

Functional Significance of Floral Biodiversity

The seasonal abundance of coccinellids and their prey was recorded on the rice crop and the surrounding flora (Shanker *et al*., 2018). Coccinellids abundant in rice ecosystem was found to establish on weed flora surrounding rice fields before moving into the rice crop. Similarly, an outward movement from rice crop to weeds was observed after harvest of the rice crop. Coccinellid prey range assessed using PAGE electrophoresis indicated that the leafhoppers and aphids on the weeds were the prey of the coccinellids before they colonized the rice fields. The alternate prey such as *Aphis gossypii* Glover, *Aphis craccivora* (Koch), *Cicadulina bipunctata* (Melichar), *Schizaphis graminum* (Rondani), *Sitobion* sp., *Thaia oryzivora* Ghauri and *Zygina maculifrons* Matsumura infesting weed flora surrounding rice fields were utilized by coccinellid predators - *Harmonia octomaculata* (Fabricius), *Micraspis discolor* (F.), *Propylea dissecta* (Mulsant), *Coccinella transversalis* Fabricius, *Cheilomenes sexmaculata* (Fabricius), *Scymnus nubilus* Mulsant and *Brumoides suturalis* (Fabricius).

Potted rice plants exposed to leafhopper/ planthopper adults for oviposition were used as bait for assessing parasitisation in the field with and without a flower border. The freshly emerged parasitoids were exposed to newly opened flowers of the border plants in the laboratory. The survival of adults was observed in comparison to the parasitoids directly offered honey and those without any nectar source. The mean percent parasitisation of

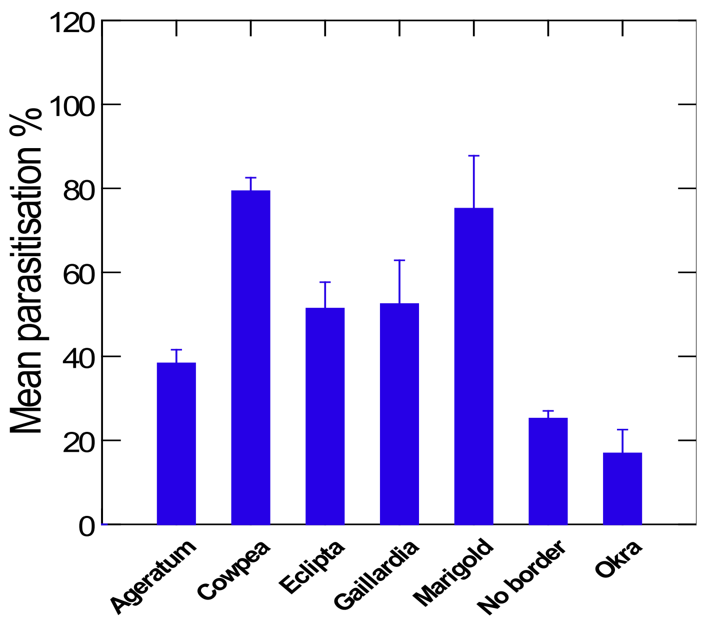

Fig. 1. Impact of floral diversity on rice bunds on egg parasitisation of plant hoppers

hopper eggs ranged from 22.53–77.91 per cent and was significantly higher in plots with flowering borders of *Vigna*, *Ageratum* and *Eclipta* (LSD = 24.15, P=0.01). The longevity of the parasitoid, *Gonatocerus* sp., (in days) was highest on *Eclipta* (7.11±1.45) followed by *Tagetus* (6.83±1.40) and *Tridax* (6.35±1.37). The longevity of *Oligosita* sp. increased 10-fold when offered food/ nectar source. Flowering plants both enhanced longevity and parasitisation.

In addition to *in situ* conservation of flowering weeds, studies on various bund crops such as *Tagetus erecta* L. (Asteraceae), *Vigna unguiculata* L., *V. mungo* (L.) Hepper, *V. radiata* (L.) R. Wilczek, *Crotalaria juncea* L. (Fabaceae), *Coriandrum sativum* L. (Apiaceae), and *Abelmoschus esculentus* (L.) Moench (Malvaceae) were tested and validated in multi-locations. Commercial flowers, pulses, vegetables green manure crops can be grown on bunds. Hopper populations were significantly lower in fields with a bund crop and limited use of insecticide (0.11 to 7.11/ hill) compared to farmers' practice fields with average of five sprays in a season and with no bund crop (9.22/hill) and untreated control (433/ hill). Bund crops had significant impact on parasitism of hopper eggs compared to plots without flower borders (F= 4.91; df 7; p <0.01). Highest parasitism of hopper eggs was observed in plots with black gram border (45.6 %) while the lowest was observed in farmer's practice plots without flower border (11.4%). However, highest benefit: cost ratio of 5.25 was recorded in rice fields with marigold as bund crop due to additional economic gain while the lowest ratio of 2.64 was observed in farmers' fields without bund crop. Integrated biodiversity conservation of flora and fauna can reap rich ecological benefits (Fig 2).

Future Prospective and Action Points

1. The impetus on organic farming and the use of alternative methods of pest management point towards the use of habitat management strategies for in situ conservation of floral and faunal diversity of agro ecosystems and harnessing their ecosystem services.
2. Government support for organic methods and the need to double the income of farmers is a two-edged sword. The use of low-cost technologies that rely on conservation tactics can help farmers to reduce pest management costs while reaping some extra monetary returns.
3. Rice paddies can also be considered as conservation habitat for avian biodiversity and host numerous winter migrants. Our observations indicate rice fields and surrounds to harbour 170 species of birds over the year.
4. Odonate diversity is also the highest in rice paddies. This group has many endangered species and

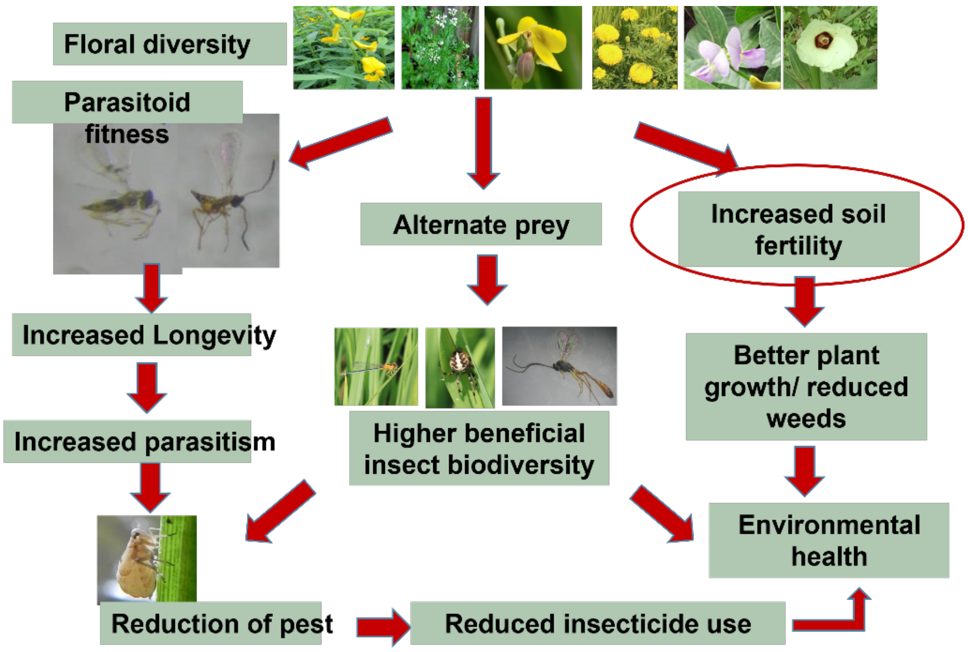

Fig. 2. Ecological benefits of Biodiversity management in rice paddies

biodiversity management in rice paddies can be the way forward for conservation of such threatened taxa.

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