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Diversifying seed mixtures for habitat management and integrated pest management

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Abstract
The use of pesticides and other approaches that treat only the symptom of high pest density are unsustainable, and should be the last, rather than the first, line of defence. It is important to understand how natural enemies function within the ecosystem and how to promote their abundance and effectiveness through habitat management and other cultural management approaches. Habitat management with field margins and other non-crop habitats manipulates the environment in order to enhance the survival of natural enemies and to improve their efficiency as pest control agents. Mixtures of so-called "insectary" plants can provide nectar and pollen all season long if properly maintained, but they must be selected with care. Because beneficial insects differ in the size and structure of their mouth-parts, not all flowers are equally accessible (or valuable) to all species.

Keywords: Natural enemies, habitat management, insectary

Introduction
A fundamental shift to a total system approach for crop protection is urgently needed to resolve the escalating economic and environmental consequences of combating agricultural pests solely with pesticides. The underlying principle of such an approach is that components of agricultural ecosystems interact, and through a series of feedback loops, maintain balance within fluctuating functional bounds. The use of pesticides and other approaches that treat only the symptom of high pest density are unsustainable, and should be the last, rather than the first, line of defence. To this end, it is important to understand how natural enemies function within the ecosystem and how to promote their abundance and effectiveness through habitat management and other cultural management approaches (an approach termed conservation biological control). Habitat management with field margins and other non-crop habitats manipulates the environment in order to enhance the survival of natural enemies and to improve their efficiency as pest control agents [1]. Halland *et al.* (2011) [2] advocated that at least 10 per cent of all agricultural land be set aside in the form of non-crop habitat such as hedges, woodlots, weedy strips and small patches of natural vegetation or for planting of low-input agricultural habitats in order to stop the decline of biodiversity in agricultural fields and the subsequent loss of biological control functions. Many studies showed that the wide range of insect predators and parasitoid families use a floral pollen and nectar.

Habitat management with field margins and other non-crop habitats manipulates the environment in order to enhance the survival of natural enemies and to improve their efficiency as pest control agents [1]. Field margins are an important type of habitat which serves as well as a refuge and a site of food resources for many arthropods. Thus, field margins play a key role in maintaining biological diversity on farmland. In addition, it may be useful to combine these semi-natural habitats with low-input agriculture to enhance effects on fauna diversity and natural pest control [3, 4].

Mixtures of so-called "insectary" plants can provide nectar and pollen all season long if properly maintained, but they must be selected with care. Because beneficial insects differ in the size and structure of their mouthparts, not all flowers are equally accessible (or valuable) to all species. The flower mixture should contain a diversity of plant species with different bloom periods and flower sizes, structures, and colors in order to benefit the maximum number of beneficial insects. These mixtures could be of immense utility in conserving and improving natural enemy fitness in areas intensively dominated by providing natural enemies with nectar, pollen, physical refuge, alternative prey, alternative hosts (Viggiani, 2003) [5] and lekking sites

(Sutherland *et al*., 2001) [6] for mating. In addition, Haaland *et al*. (2011) [2] found sown wildflower strips to be attractive to hymenopterans parasitoids while also offering 65 valuable sources of sugar. Plantation of species-rich wildflower strips of 1.5 m distance are one of the most crucial elements for agro-environmental program in developed nations. However, such seed mixtures include annual, biennial and perennial plants that are native to a particular country/region. Since resource poor hill farmers cannot afford to the escalating costs associated with pest control, optimizing such composite seed mixture would be crucial element of pest management programme in Jammu and Kashmir.

Materials and Methods

Plants Identified

A total of 14 plant species that were identified optimally attractive to natural enemies. Our identified plant species consisting of Chrysanthemum (*Chrysanthemum morifolium*), Pigweed (*Amaranthus retroflexus*), California poppy (*Eschscholzia californica*), Pot marigold (*Calendula officinalis*), Candytuft globe (*Iberis umbellate*), Tickseed (*Coreopsis gigantean*), Cornflower (*Centaurea cyanus*), Sundance Bicolor (*Gaillardia pulchella*), Buckwheat (*Fagopyrum esculentum*), Coriander (*Coriandrum sativum*), Berseem (*Trifolium alexandrinum*), Wild carrot (*Daucus carota*), Bishop weed (*Aegopodium podagraria*) and Fennel (*Foeniculum vulgare*). These plants are easily available, relatively cheap and easy to grow.

Composite Mixture

Seeds of the identified plants that are survived well in both sandy and clay soils and provided continuity of bloom with minimum care (i.e. regular watering and weeding during establishment). Composite mixture comprising different proportion can be formed below:

Table 1: Composite mixture comprises different proportion of seeds of selective plant species.

Common name	Scientific name	Family	Proportion (gm) composite seed mixture
Chrysanthemum	*Chrysanthemum morifolium*	Asteraceae	30
Pigweed	*Amaranthus retroflexus*	Amaranthaceae	20
California poppy	*Eschscholzia californica*	Papaveraceae	10
Pot marigold	*Calendula officinalis*	Asteraceae	15
Candytuft globe	*Iberis umbellate*	Brassicaceae	10
Tickseed	*Coreopsis gigantean*	Asteraceae	20
Cornflower	*Centaurea cyanus*	Asteraceae	15
Sundance Bicolor	*Gaillardia pulchella*	Asteraceae	25
Buckwheat	*Fagopyrum esculentum*	Polygonaceae	40
Coriander	*Coriandrum sativum*	Apiaceae	20
Berseem	*Trifolium alexandrinum*	Fabaceae	10
Wild carrot	*Daucus carota*	Apiaceae	20
Bishop weed	*Aegopodium podagraria*	Apiaceae	10
Fennel	*Foeniculum vulgare*	Apiaceae	10

Evaluate the seed mixtures in field for natural control

Two plots of vegetable crop were formed. In first plot, seed mixtures (treatment) was sparsed at effective distance as border row around vegetable field while other plot was not provisioned with any composite mixture (control)**.** Abundance of insect pests/ natural enemy's population was recorded.

Results

Plants Identified

A total of 14 plant species were identified to grow around vegetable field (Table 1). All the plants consisting of Chrysanthemum (*Chrysanthemum morifolium*), Pigweed (*Amaranthus* retroflexus), California poppy (*Eschscholzia californica*), Pot marigold (*Calendula officinalis*), Candytuft globe (*Iberis umbellate*), Tickseed (*Coreopsis gigantean*), Cornflower (*Centaurea cyanus*), Sundance Bicolor (*Gaillardia pulchella*), Buckwheat (*Fagopyrum esculentum*), Coriander (*Coriandrum sativum*), Berseem (*Trifolium alexandrinum*), Wild carrot (*Daucus carota*), Bishop weed (*Aegopodium podagraria*) and Fennel (*Foeniculum vulgare*) were found as promising nectar or pollen sources for all or some of natural enemies and pollinators.

Evaluate the seed mixtures in field for natural control

During the experiment, higher percentage of pollinators (32%), natural enemies (50%) and lower percentage of pest population (18%) were observed in treatment plot (provisioned with seed mixture) as compared to the control plot (provisioned without seed mixture) consisting of pollinators (28%), natural enemies (43%) and pest population (29%) (Fig. 1).

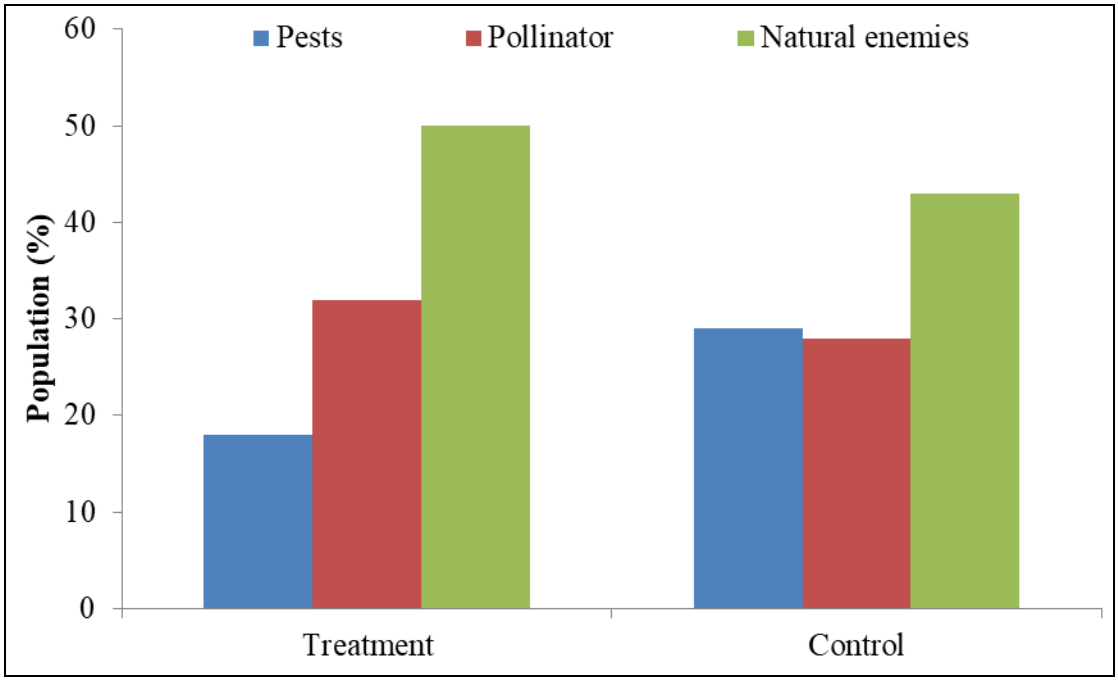

Fig 1: Comparison of pests, pollinator and natural enemies complex between treatment and control.

Discussion

In our study, higher percentage of pollinators (32%), natural enemies (50%) and lower percentage of pest population (18%) were observed in treatment plot (provisioned with seed mixture) as compared to control plot (provisioned without seed mixture) consisting of pollinators (28%), natural enemies (43%) and pest (29%) population. Therefore, treatment plot provisioned with seed mixture which consisting higher number of attracting plants that attracts natural enemies as compared to control plot. Qureshi *et al.*, (2009) [7] also suggested that the population of beneficial and harmful insects, with a focus on silverleaf whitefly and aphids, and other invertebrates were sampled weekly on four different crops which could be used for habitat manipulation: Goodbug Mix (GBM; a proprietary seed mixture including self-sowing annual and perennial herbaceous flower species), lablab (*Lablab purpureus* L. Sweet), lucerne (*Medicago sativa* L.) and niger (*Guizotia abyssinica*). These mixtures are to grow around vegetable field to attract and increase beneficial insects and spiders for the control of sap-sucking insect-pests. Use of these bio-control strategies affords the opportunity to minimise pesticide usage and the risks associated with pollution. The success of wildflower strips can however be enhanced by a careful selection of the sown species to benefit particular target species in the form of the seed mix which should also be tailored to provide resources for all life history stages, for example, larval host plants and adult nectar sources. Many organic growers subscribe to the idea of providing resources for natural enemies in cropping systems. However, because little research exists to guide their decision-making, farmers are frequently left to experiment with various plant species or more often resort to commercially available beneficial insect habitat (BIH) seed mixtures. No doubt many commercial mixes: Border Patrol™ (BP) (Braman *et al.*, 2002) [8]. Beneficial Insect Mix (BIM), and Good Bug Blend (GBB) are now been marketed but companies selling these mixtures, often make unsupported claims that their product can reduce or eliminate insect pest problems. A scientific validation is therefore always required. In general, the more species the better, since a greater diversity of plants will benefit more species of insects but it is also sensible to avoid species that are in the same botanical family. For instance, research conducted at NMSU's Los Lunas Agricultural Science Center has shown that the mixture–comprising California bluebell (*Phacelia campanularia*), buckwheat (*Fagopyrum esculentum*), dill (*Anethum graveolens*), plains coreopsis (*Coreopsis tinctoria*), garden cosmos (*Cosmos bipinnatus*), and sweet alyssum (*Lobularia maritima*) can significantly increase populations of several groups of important predatory and parasitic insects, and can therefore be a valuable component of an IPM approach. However, these mixtures are not only location specific but also crop specific. Nevertheless they are important component of farmscaping which is now a day becoming more and more popular in developed nation for conservation bio-control [9] (Dufour, 2000).

Conclusion

From the present study it can be concluded that the conservation of farmland insect biodiversity is possible through such seed mixtures with increased ecosystem services in term of entomophily and entomophagy. In Jammu and Kashmir, resource poor hill farmers cannot afford to the surging costs associated with pest control. Therefore, plantation of species-rich wildflower strips of annual, biennial and perennial plants that are native to a particular region would be crucial element of pest management programme for farmers.

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