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Review Article

Role of Intercropping Practices in Farming System for Insect Pest Management

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Abstract

From the onset of agricultural modernization, farmers and researchers have been faced many hurdles arising from the homogenization of agricultural systems: an increased vulnerability of crops to insect pests and diseases, insecticides resistance, and environmental pollution. The adoption and expansion of monocultures has decreased the abundance and activity of natural enemies by destruction of critical food resources and overwintering sites. For this reason, adoption of suitable intercropping combination is necessary in present time to tackle the agroecosystems from vulnerable to pest outbreaks and other environmental problems. The successful use of intercropping to manage pests depends on a thorough knowledge of insect ecology and crop characteristics.

Keywords: Agroecosystems; Ecology; Insect; Intercropping; Monoculture; Natural Enemies

Introduction

From the time of agricultural modernisation, farmers and researchers have faced many ecological problems arising from the homogenisation of agricultural systems: the increased infestation of crops to arthropod pests and diseases which can be severe when infesting genetically uniform, large-scale monocultures. Worldwide, 91% of the 1.5 billion ha of cropland are under annual crops, mostly monocultures of wheat, rice, maize, cotton and soybeans [1]. Monocultures may have temporary economic advantages for farmers, but in the long term they are not beneficial in ecological point of view. Rather, the drastic narrowing of cultivated plant diversity has put the world's food production in greater peril [2]. To manage insect pests in an eco-friendly manner, a pest-suppressive agro-ecosystem has to be considered. A pest-suppressive agro-ecosystem can be designed by identifying a suitable intercrop having insect pest deterrence, and a border crop enhancing natural enemy activity by acting as a refugium [3].

Intercropping is a cultural practice in Integrated Pest Management (IPM) system involving the growing of different crops in the same field. There are many spatial combinations possible for intercropping, including mixed intercropping, in which different crops are planted in the same row or without regard to row, and row intercropping, which involves planting different crops in alternating rows. Although it is an old practice but the recent interest in intercropping as an IPM tool is the result of concerns about potential negative impacts of pesticide on human health and the environment, pesticide resistance, resurgence of insect pest and general considerations of agricultural production.

Hypotheses of pest management in diversified cropping system

Diversified cropping systems, such as those based on intercropping and agroforestry or cover cropping of orchards is getting interest now-a-days because these are more stable and resource-conserving in nature [4]. Many of these attributes are connected to the higher levels of functional biodiversity associated with complex farming systems. As diversity increases, so do opportunities for coexistence and beneficial interference between species that can enhance agroecosystem sustainability [5]. Helenius [6] observed that the reduction of monophagous (specialist) pests was greater in perennial systems because of more diversity prevail there. The planting of buckwheat as a cover crop in apple orchard in New Zealand enhances the activity of *Dolichogenidea tasmanica*, the key parasitoid of an important leaf roller pest, *Epiphyas postvittana* by providing adult foods like pollen and/or nectar [7]. It is found that when cotton was intercropped with sunflower, lucerne, safflower, sorghum and tomato crops, more number of predatory insects were found on lucerne followed by sunflower, safflower, sorghum and tomato [8,9].

The ecological theory relating to the benefits of mixed versus simple cropping systems revolves around two possible explanations of how insect pest populations attain higher levels in monoculture systems than in diverse ones. The two hypotheses proposed by Root [10] are [11]:

1. The enemies hypothesis, which argues that pest numbers are reduced in more diverse systems because the activity of natural enemies is enhanced by environmental opportunities prevalent in complex systems.

2. The resource concentration hypothesis, which argues that the presence of a more diverse flora has direct negative effects on the ability of insect pests to find and utilise the host plant and to remain in the crop habitat.

The enemies hypothesis attributes lower pest abundance occur in intercropped or more diverse systems whereas higher percentage of predators and parasitoids are found in diverse agro-ecosystem [12]. In monoculture system natural enemies does not thrive well as they require more than prey or hosts to complete their life cycles. So, their number can be increased by providing of nectar and pollen sources plants, which can increase parasitoid reproductive potential and abundance of alternative host/prey when the pest species are scarce or at inappropriate stages [13]. Several researchers have introduced flowering plants as strips within crops as a way to enhance the availability of pollen and nectar, necessary for optimal reproduction, fecundity and longevity of many natural enemies of pests. *Phacelia tanacetifolia* strips have been used in wheat, sugar beets and cabbage, leading to greater abundance of aphidophagous predators (especially syrphid flies) and reduced aphid populations. In England, in an attempt to provide suitable overwintering habitat within fields for aphid predators, researchers created 'beetle banks' sown with perennial grasses such as *Dactylis glomerata* and *Holcus lanatus*. When these banks run parallel with the crop rows, great enhancement of predators (up to 1500 beetles per square metre) can be achieved in only two years [3].

The resource concentration hypothesis predicts lower pest abundance in diverse communities because a specialist feeder is less likely to find its host plant due to the presence of confusing masking chemical stimuli, physical barriers to movement. In Africa, scientists at the International Center of Insect Physiology and Ecology (ICIPE) developed a habitat manipulation system (push–pull strategy) based on chemical ecology and agrobiodiversity that uses different plants in the borders and intercrop in maize fields. The strategy involves the Napier grass and Sudan grass (the 'pull') grown in border crop in maize for attracting stemborer colonisation and two plants intercropped with maize (molasses grass and silver leaf) that repel the stemborers (the 'push') [14,15]. Molasses grass, not only repel the stemborers, but also increased stemborer parasitism by a natural enemy, *Cotesia sesamiae*. The leguminous silverleaf (*Desmodium uncinatum*) has many positive effects such as it suppresses the parasitic weed Striga by root exudates which possess striga seed germination stimulation and radical growth inhibition properties which diminish striga seeds through suicidal germination and a continual reduction of the soil seed bank. Beside this, it has N-fixing ability which improves soil fertility status and improves soil organic matter content. All the tested four plants have great economic importance to farmers in Eastern Africa as they are used as livestock fodders. By adopting push–pull strategy, participating farmers in the breadbasket of Trans Nzoia are reporting a 15 - 20% increase in maize yield and substantial increase in milk production by supporting higher numbers of dairy cows on the fodder produced [11].

Variation in presence of insect population in different cropping system

Pest outbreaks are rare in polycultures due to the ability of the diverse plant culture to self-sustain through natural pest control by increasing the occurrence of natural enemies [16,17]. Letourneau [18] found parasitism of melonworm, *Diaphania hyalinata,* higher in squash that was intercropped with corn and common bean than in monocropped squash. Hawkes and Coaker [19] reported that the anthomyiid *Delia brassicae* oviposited less on *Brassica* sp. intercropped with clover than in pure crop. When eggplant was grown with maize as border crop and coriander as intercrop or marigold as intercrop had the lowest leafhopper and whitefly incidence. Maize likely acted as a barrier crop for the movement of leafhoppers due to its tall height [10,20]. In case of pigeonpea, leafhopper populations were less when intercropping with sorghum [21]. It was also noticed that maize harbored large numbers of coccinellids and syrphids, which might have helped to reduce the leafhopper nymphs on eggplant in those treatments. The border crop and intercrop change the microclimate of the main crop, which in turn hinders insect pest development and favors natural enemy proliferation by providing supplementary food and refugia [22]. Moreover, the volatiles from coriander and marigold likely acted to repel leafhoppers, resulting in smaller populations than the sole crop [23]. Similarly, Hilje and Stansly [24] reported that *Bemisia tabaci* abundance and begomovirus incidence were low on tomato intercropped with coriander. It is also anticipated that weak fliers with unsophisticated host-finding mechanisms, such as whiteflies and aphids, might be reduced in polyculture cropping system. Simply by alighting on and probing various intercrops, such insects might invest less time in damaging main crops [25].

Trap cropping

Trap cropping is another cultural method of pest suppression that relies on manipulating host-finding mechanisms. It can involve both traditional intercropping, in which the trap crop and main crop are grown together, as well as relay intercropping systems in which the trap crop and main crop are grown in sequence [16]. The objective is to influence the herbivore's decision-making before it finds and damages the main crop. Actually a trap crop is a plant that draws a pest away from the main crop. Effective use of trap crops requires that insects concentrated on trap crops must be destroyed by spraying or any other means before they disperse to other plants.

Main crop	Trap crop	Pest controlled
Bengal gram	Marigold	*Heliothis sp.*
Cowpea	Cotton	*Heliothis sp.*
Soybean	Corn	*Heliothis sp.*
Beans	Soybean	Mexican bean beetle
Beans and other legumes	Corn	Leaf hopper, Leaf beetles, Stalk borer Fall armyworm
Sunflower	Cotton	*Heliothis sp.*
	Marigold	*Heliothis sp.*
Groundnut	Cowpea	Leaf folder
Mustard	Cabbage	Cabbage head borer
Cotton	Marigold	*Heliothis sp.*
	Alfa alfa (Strip Intercrop)	Laygus bug
	Cowpea (1 rows intercrop, planted in every 5 rows of cotton)	*Heliothis sp.*
	Chick pea	*Heliothis sp.*
	Corn (1 rows intercrop, planted in every 20 rows of cotton)	*Heliothis sp.*
Tomato	Cabbage	Diamondback moth
	Marigold (2 rows planted in every 14 rows of Tomato)	Tomato fruit borer and Root Knot nematodes
Brinjal or eggplant	Coriander/ Fennel (1 rows planted in every 2 rows of Brinjal)	Shoot and Fruit borer
Cabbage	Radish (Planted in every 15 rows of Cabbage)	Flea beetle
	Indian Mustard (2 rows planted in every 25 rows of cabbage)	Diamondback moth
	Nasturtium	Aphids, Flea beetle, Cucumber beetle
Radish	Cabbage family	Flea beetle Root maggot
Potato	Marigold	Nematodes

Table 1: Examples of some intercrop used as trap crop in farming practices.
Source: Dewangan and Sahu [26].

Conclusion

One of the major hurdles in choosing the right intercrop combination for pest suppression is to determine which combinations will reduce pest abundance, since all combinations of crops will not produce the desired effect. So, intercrop can be a used as sole approach to pest management or it can be combined with other pest management strategies such as host-plant resistance, augmentative biological control, and chemical control. The successful use of intercropping to manage pests depends on a thorough knowledge of how distinct crop characteristics and combinations will influence the behavior of pest and beneficial arthropods.

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