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**Samik Chowdhury**
Department of Agricultural Entomology, Palli Siksha Bhavana, Visva-Bharati Sriniketan, West Bengal, India

**T Boopathi**
ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram, India

**Hirak Chatterjee**
Department of Agricultural Entomology, Palli Siksha Bhavana, Visva-Bharati Sriniketan, West Bengal, India

**Ardhendu Chakraborty**
Department of Agricultural Entomology, Palli Siksha Bhavana, Visva-Bharati Sriniketan, West Bengal, India

**Corresponding Author:**
**Samik Chowdhury**
Department of Agricultural Entomology. Palli Siksha Bhavana, Visva-Bharati Sriniketan, West Bengal, India

# Effect of ecological engineering through border cropping for enhancing population of *Micraspis crocea* (Mulsant) towards suppression of rice leaf folder (*Cnaphalocrocis medinalis* Guenee) in rice

**Samik Chowdhury, T Boopathi, Hirak Chatterjee and Ardhendu Chakraborty**

## Abstract
Field experiments were conducted in 2017-18 and 2018-19 at the ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram to develop ecological engineering cropping systems for non-rice crops such as cowpea, pigeon pea, sesame, okra, eggplant, and chilli as border crops with the main crop rice (Gomati Dhan). These systems aimed to improve entomophages and suppress insect-pests in the rice ecosystem while maintaining zero insecticide conditions. Ecological engineering parameters such as pest defender ratio, occurrence ratio (OR) of entomophages, preference ratio (PR), biodiversity indices (species diversity, richness, and evenness) of entomophages and insect-pests, and cost benefit ratio (CBR) were assessed for all cropping systems. The population of *Micraspis crocea* (Mulsant) on rice was maximum as influenced by non-rice border cropping systems like, (rice + pigeon pea) and (rice + cowpea). However, (rice + sesame) (rice + okra), (rice + eggplant) and (rice + chilli border cropping systems affected the population of entomophages moderately than rice alone. Minimum population of *Cnaphalocrocis medinalis* was recorded in, (rice + pigeon pea) and (rice + sesame) bund system as compared to rice alone which registered maximum population and damage., Further, moderate population and damage of pests was registered in (rice + cowpea), (rice + okra) (rice + eggplant) and (rice + chilli) border cropping systems. Pest defender ratio was maximum on (rice + pigeon pea) and (rice + sesame) (1: 4.94, and 1: 4.73) border cropping systems followed by (rice + cowpea) (1. 3.27), (rice + okra) (1: 2.71), (rice + eggplant) (1: 2.60) and (rice + chilli) (1: 2.45) border cropping systems when compared to rice alone (1: 1.78). Highest OR of entomophages; minimum PR of pests; maximum species diversity, richness and evenness for entomophages and insect-pests; maximum yield; and higher CBR were estimated on (rice + pigeon pea), (rice + cowpea) and (rice + sesame) border cropping systems than on (rice + okra), (rice + eggplant), (rice + chilli) and rice alone cropping systems.

**Keywords:** Ecological engineering, aroma rice varieties, non-aroma rice varieties, cost benefit ratio (CBR), pest defender ratio, occurrence ratio (OR) and preference ratio (PR)

## Introduction
The Indo-Burma border, also known as the India-Myanmar border, connects the Myanmar states of Sagaing, Kachin, and Chin with Arunachal Pradesh, Nagaland, Manipur, and Mizoram sprawling over 1,600 kilometers of thick woodlands, steep hills, and rivers. (Hazarika and Routledge, 2016) [14]. Highly fertilized rice and practicing multi-cropping techniques through-out the year foster insect pest populations and lowering rice productivity in this region. (Boopathi *et al*., 2018) [4]. Insects and entomophages are essential components of the rice ecosystem in Northeast India and Indo-Burma. Out of 122 insects and mites collected in Assam from rice field 85 were pests, whereas 37 were natural enemies. Stem borers, leaf folders, and planthoppers were the main pests, whereas spiders, ladybird beetles, and hymenopteran parasitoids were the main natural foes. (Das *et al*., 2016) [6-7]. In another study in Manipur recorded 30 insect-pests and 31 natural enemies among 61 total collection in rice. Leaf folders, stem borers, and green leafhoppers were the main pests, whereas spiders, coccinellids, and egg parasitoids were the main natural foes. (Wahengbam *et al*., 2019) [26]. Rice leaf folders (*Cnaphalocrocis medinalis*) are the most common paddy pests in India, notably in Mizoram, and are found in all rice-growing regions during the rainy season, where they thrive in gloomy, low-light circumstances (Kalode *et al*., 1994; Boopathi *et al*., 2012) [16, 3]. and its infestation might lose 30–80% yield. (Boopathi *et al*., 2012) [4].

Over use of insecticides kill both target pests and their natural antagonists, which can increase pest populations. (Dent, 2000) [8] Insecticide resistance makes the pest management harder (Johnson, 2015) [15] also affect the environmental equilibrium, making more pests survival. (Altieri, 1994) [2]. Thus, pesticides should be used sparingly and alternate pest management methods should be explored to reduce environmental and pest-natural enemy impacts. Conservation biological management (CBC) of existing entomophages in rice cropping systems with enhanced biological properties has gained interest. Conservation biological management (CBC) promotes natural pest foes and reduces amount of synthetic insecticides. CBC has been popular in Northeast India and Indo-Burma as a sustainable pest management approach that shelters natural enemies and reduces insect numbers and yields. (Hazarika *et al*., 2016) [14]. Another Nagaland study revealed that CBC methods like intercropping with legumes and keeping natural vegetation increased natural enemies and decreased pests. (Sarma *et al*., 2014) [22]. Ecological engineering preserves, improves and expands natural enemy populations and field availability. Cultural techniques, mostly focused on vegetation management, encourage biological control or "bottom-up" pest management in ecological engineering. (Gurr *et al*., 2004b) [11]. Thus, studies show the intricate interactions between pests and natural enemies in Northeast Indian and Indo-Burmese rice ecosystems and the need to include ecological aspects in pest management to maintain ecosystem balance.

## Materials and Methods

### Study site and experimental design

This research will examine how non-rice affect population dynamics and natural enemy performance on rice pests (*Oryza sativa* L.). Ecological engineering materials and processes are covered in this chapter.

Two *kharif* seasons of 2017–18 and 2018–19, the current investigation was conducted at the research farm of the ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram, India. The molecular identification of important entomophages (parasitoids and predators) carried out at central lab of the ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram, India.

Gomati rice was planted in 760 $m^2$ of well-prepared soil. 20 cm separated rows and plants with Seed rate was 4 kg/ha. Redgram (Pusa 992), cowpea (Yard Bean 7), sesamum (Tripura Siping), okra (Arka Anamika), chilli (Pusa Jawala), and brinjal (Pusa Purple Cluster) were grown as bund crops (one $m^2$) surrounding rice (Gomati Dhan) on different dates to coincide with rice flowering. Treatment plots were 20 $m^2$. A Randomized Block Design (RBD) with three replications had seven treatments and a control. To sustain healthy rice and border crops in ICAR Research Complex for NEH Region and Mizoram Centre's, good agronomic practices were followed except pest management. The second season of this experiment used comparable non-rice crops and approaches.

**Table 1:** Crop varieties and time of sowing of non- rice crop varieties as trap crops and main crop

| Sl. No. | Variety name | Time of Planting |
|---|---|---|
| 1. | Redgram (Pusa 992) | 40 days after main plant transplanting |
| 2. | Cowpea (Yard Bean 7) | 40 days after main plant transplanting |
| 3. | Sesamum (Tripura Siping) | 40 days after main plant transplanting |
| 4. | Okra (Arka Anamika) | 40 days after main plant transplanting |
| 5. | Chilli (Pusa Jawala) | 40 days after main plant transplanting |
| 6. | Brinjal (Pusa Purple Cluster) | 40 days after main plant transplanting |
| 7. | Gomati Dhan (Main Crop) | At the time of main plant transplanting |

### Effects of aroma rice on the population of the species *Micraspis crocea* (Mulsant) and *Cnaphalocrocis medinalis* (Guenee)

### Field experiments

Ten plants were randomly chosen from each treatment, and an in situ count was done each week in the early morning hours. The total number of *Micraspis crocea* (Mulsant) was counted in rice from the leaves of hills and represented as numbers/hill. At the same time, observations were also made in all the border crops.

### Occurrence ratio

Similarly, by using *in-situ* counts, occurrence ratio (OR) of predators and parasitoids as the case may be on pigeon pea, cowpea, okra, brinjal, chilli and sesamum intercrops and weed species was estimated by using following formula of Muthukrishnan and Dhanasekaran (2014) [19].

$$\text{OR} = \frac{\text{Population of natural enemies on non rice bund crops}}{\text{Occurrence of natural enemies on rice crop}}$$

### Cost Benefit Ratio (CBR)

Benefit Cost Ratio was worked out for all the field experiments, using the formula of Akila and Sundara Babu, 1994 [1].

$$\text{CB Ratio} = \frac{\text{Cost of produce}}{\text{Cost of cultivation} + \text{Cost of plant protection}}$$

### Statistical analysis

Mean number of insects for the pooled year was determined for each week during Kharif season in both year 2017-18 and 2018-19. Data analyses were with methods of Gomez and Gomez (Gomez and Gomez, 1984) [10] using SAS Software Version 9.3 (SAS, 2011). Data were analyzed using one ANOVA for population of C. medinalis and Micraspis crocea during two seasons. All ANOVA were performed on original values. If interactions were significant they were used to explain the results. If interactions were not significant means were separated using Tukey's HSD test. Critical difference values were calculated at five per cent probability level and treatment mean values were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1951) [9].

## Results and Discussion

The impact of border crops on the incidence of *Cnaphalocrocis medinalis* and *Micraspis crocea* was investigated through a field study, which revealed significant variations among different border cropping systems. The average population of *Cnaphalocrocis medinalis* was found to be 6.55±0.24 per hill on pure rice crop, grown without any border crops. The minimum population of *Cnaphalocrocis medinalis* was observed in rice crops border crop with pigeon pea (2.69±0.11 per hill), cowpea (2.33±0.09 per hill), and chilli (3.10±0.12 per hill). Conversely, higher populations of *Cnaphalocrocis medinalis* were observed in rice crops border cropping with sesame (4.86±0.21 per hill), eggplant (4.73±0.28 per hill), and okra (4.57±0.31 per hill) (Table 2).

The mean population of *Micraspis crocea* was significantly higher (8.52±0.44 per hill) in non-rice-based border cropping systems than in pure rice crops (3.36±0.13 per hill). Among the different border cropping systems, rice crops border cropped with pigeon pea recorded the highest population of *Micraspis crocea* (8.52±0.44 per hill) on rice plants, followed by rice crops border cropped with cowpea (7.31±0.33 per hill) and chilli (6.79±0.41 per hill). Conversely, rice crops border cropped with sesame, okra, and eggplant border cropping systems registered lower populations of *Micraspis crocea* (4.86±0.21, 4.57±0.31, and 4.73±0.28 per hill) (Table 2).

Among the non-rice crops used as border crops, pigeon pea had the highest population of *Micraspis crocea* (8.80±0.43 per plant), followed by cowpea (7.68±0.41 per plant) and chilli (7.61±0.27 per plant). In contrast, sesamum (4.25±0.18 per plant), okra (3.35±0.13 per plant), and eggplant (2.17±0.12 per plant) had the least population of *Micraspis crocea*. The occurrence ratio of *Micraspis crocea* for pigeon pea, cowpea, chilli, sesamum, okra, and eggplant were 1.19, 1.16, 1.12, 0.84, 0.73, and 0.59, respectively. Pigeon pea as a non-rice crop used in border cropping systems, has been found to attract a higher number of entomophages compared to other border crops. The flowers of pigeon pea are yellow in color and produce nectar, which attracts a variety of natural enemies like *Micraspis crocea* of pests. Pigeon pea border crops had a higher population of entomophages, such as spiders and ladybirds, compared to other border crops like sesame, okra, and eggplant in North_east India (Das *et al*., 2015) [5]. Another study found that the yellow flowers of pigeon pea were highly attractive to several species of bees and wasps, which are important pollinators and natural enemies of pests (Mishra *et al*., 2015) [18]. In the case of the non-rice crop pigeon pea border cropping system, the population of *Micraspis crocea* was highest at 33-36 SWM, with 13.85±0.70, 13.52±0.06, 11.08±0.32, and 10.25±0.02 per plant, respectively. However, after 37 SWM, there was a reduction in the population of *Micraspis crocea*. (Fig. 1).

**Table 2:** Effect of non-rice border cropping systems on population of *Micraspis crocea* and *Cnaphalocrocis medinalis*

| Border cropping system | Mean *C. medinalis* population (No./tiller) | Mean *Micraspis crocea* population (No./plant) | | Occurrence ratio |
|---|---|---|---|---|
| | Main crop | Main crop | Border crop | |
| Rice + Pigeon pea | 2.69$^{a}$±0.11 | 8.52$^{a}$±0.44 | 8.80$^{a}$±0.43 | 1.19 |
| Rice + Cowpea | 2.33$^{b}$±0.09 | 7.31$^{b}$±0.33 | 7.68$^{b}$±0.41 | 1.16 |
| Rice + Chilli | 3.10$^{b}$±0.12 | 6.79$^{b}$±0.41 | 7.61$^{b}$±0.27 | 1.12 |
| Rice + Sesame | 4.86$^{b}$±0.21 | 5.19$^{c}$±0.18 | 4.25$^{c}$±0.18 | 0.84 |
| Rice + Okra | 4.57$^{c}$±0.31 | 4.78$^{c}$±0.30 | 3.35$^{d}$±0.13 | 0.73 |
| Rice + Eggplant | 4.73$^{cd}$±0.28 | 4.26$^{cd}$±0.15 | 2.17$^{e}$±0.12 | 0.59 |
| Rice alone | 6.55$^{d}$±0.24 | 3.36$^{d}$±0.13 | | |
| df | 2,6 | 2,6 | 3,5 | |
| F value | 69.40 | 33.39 | 142.31 | |
| P value | <0.001 | <0.001 | <0.001 | |

*Data are mean values of main crop three replications and four replication for border crop
Mean value ± standard Error
In a columns means followed by same letter(s) are not significantly different (P=0.05) by DMRT

The cultivation of trap crops and intercrops involves growing certain plant species to lure beneficial organisms such as predators and parasitoids, which can safeguard the main crops against pest infestations. By planting bean, okra and redgram together in a bundle, it was anticipated that an increase in structural diversity would result in a higher population of predatory organisms, especially spiders. This approach aims to provide more advantages, particularly in situations where excessive use of insecticides and intensive chemical management are unnecessary (Swinton *et al*., 2006) [25]. Another study found that the use of trap crops like maize and sunflower in tomato fields resulted in higher populations of parasitoid wasps, which are important natural enemies of pests like the tomato fruit borer (Rahman *et al*., 2018) [21]. Successful habitat management is essential for maximizing ecosystem services in agricultural systems. Ecosystem services refer to the benefits that people receive from nature, such as pollination, pest control, and nutrient cycling. Habitat management practices that promote biodiversity, such as the use of cover crops, hedgerows, and conservation tillage, can enhance the provision of ecosystem services in agricultural landscapes (Kremen and Miles, 2012) [17]. The use of non-rice mustard and pigeon pea intercrops and trap crops has been shown to increase the population of entomophages, or natural enemies like *Micraspis crocea* (Mulsant), *Harmonia octomaculata* (F.), *Ophionea nigrofasciata* (Schmidt-Goebel), *Agriocnemis feminafemina* (Brauer), *Agriocnemi spygmaea* (Rambur), *Pardosa pseudoannulata* (Boesenberg & Strand), *Oxyopes javanus* Thorell, *Oxyopes lineatipes* (C.L. Koch) of pests, in agricultural systems (Rahman *et al*., 2014) [20]. Another study conducted in India found that the use of trap crops like marigold and sunflower in vegetable fields increased the populations of parasitoid wasps like *Diadegma insulare*, *Microplitis plutellae* and *Diadromus subtilicornis*, which are important natural enemies of pests like the diamondback moth (Suresh *et al*., 2016) [24]. These findings suggest that incorporating intercrops and trap crops into agricultural systems can enhance the provision of natural pest control services, leading to more sustainable and eco-friendly farming practices.

Border cropping systems have been found to have a significant impact on the population of beneficial insects like

*Micraspis crocea*, which can aid in the control of *Cnaphalocrocis medinalis* populations. Effect of different border cropping systems on the population of *Micraspis crocea*, an important natural enemy of pests like *Cnaphalocrocis medinalis*, *Cnaphalocrocis trapezali*, *Chilo suppressalis and Spodoptera mauritia* in rice ecosystems (Das *et al*., 2016) [6-7]. Border cropping systems have been shown to be effective in suppressing the population of rice leaffolder, a major pest in rice fields. For instance, a study conducted in Vietnam found that the abundance of the rice leaffolder was significantly lower in rice fields with border crops than in those without border crops, leading to higher rice yields in fields with border crops (Ha *et al*., 2018) [12]. Similarly, a study conducted in India found that non-rice crops like cowpea, pigeon pea, and chilli as border crops resulted in lower populations of rice leaffolder in rice fields, leading to higher yields of rice (Das *et al*., 2016) [6-7]. These findings suggest that border cropping systems can be an effective tool in reducing the population of rice leaffolder and promoting sustainable pest control in rice fields.

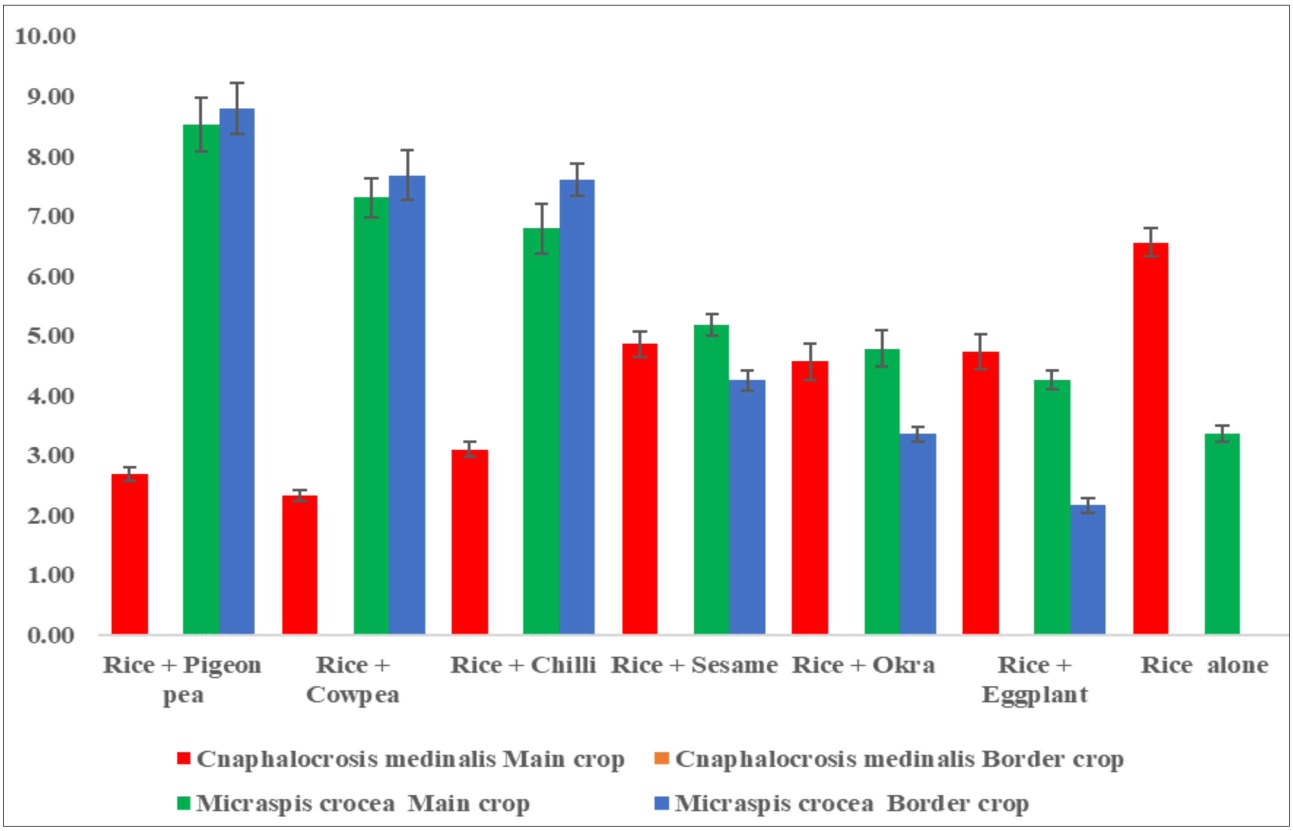


**Fig 1:** Influence of border crops on *Cnaphalocrocis medinalis* and *Micraspis crocea* population

The incorporation of border cropping systems in rice fields has been found to have a positive effect on rice yield. Conducted study showed that the Rice + Pigeon pea border cropping system had the highest rice yield (5747±251.15 kg/ha) compared to other border cropping systems like Rice + Sesame (5406±92.23 kg/ha) and Rice + Cowpea (5224±46.23 kg/ha), while rice grown alone without a border cropping system had the lowest yield (4713±196.23kg/ha). The higher yield in border cropping systems could be attributed to the increased population of natural enemies, which can aid in the control of pests, leading to higher yields (Das *et al*., 2016) [6-7] (Table 3).

The higher population of *Micraspis crocea* in border cropping systems was resulted in a decrease in *Cnaphalocrocis medinalis* populations, which explained the variation in yield. This increase in yield was also impacted the cost-benefit ratio (C:B) of rice farming. Conducted study found that the C:B ratio was favorable in border cropping systems, with ratios of 1:1.41 and 1:1.33 recorded for Rice + Pigeon pea and Rice + Cowpea systems, respectively (Das *et al*., 2016 and Rahman *et al*., 2014) [6-7, 20] (Table 3). These results suggest that incorporating border cropping systems into rice farming can not only increase yields, but also improve the cost-benefit ratio of rice production.

**Table 3:** Effect of non-rice border cropping systems on socio-economic development.

| | Rice Equivalent Yield (REY) (Kg/ha) | | Cost Benefit Ratio |
|---|---|---|---|
| | Main crop | Border crop | |
| Rice + Pigeon pea | 5747$^{a}$±251.15 | 158$^{a}$±4.84 | 1.41 |
| Rice + Cowpea | 5224$^{b}$±46.23 | 245$^{b}$±2.79 | 1.33 |
| Rice + Chilli | 4806$^{bc}$±43.42 | 121$^{c}$±2.38 | 1.28 |
| Rice + Sesame | 5406$^{bcd}$±92.23 | 51$^{d}$±0.16 | 1.22 |
| Rice + Okra | 5062$^{cd}$±195.51 | 143$^{e}$±4.40 | 1.16 |
| Rice + Eggplant | 4896$^{d}$±43.51 | 176$^{f}$±1.42 | 1.08 |
| Rice alone | 4713$^{d}$±196.23 | | 1.01 |
| df | 2,6 | 3,5 | |
| F value | 21.547 | 465.75 | |
| P value | 0.002 | <0.001 | |
| SED | 197.8 | 4.188 | |
| C.D (P=0.05) | 435.80 | 9.009 | |

*Data are mean values of main crop three replications and four replication for border crop
Mean value ± standard Error
In a columns means followed by same letter(s) are not significantly different (P=0.05) by DMRT

## Conclusion

From the above results, Rice + Pigeon pea and Rice + Cowpea could be recommended for creating flowering strips in the border of rice crop. It will increase the predator, *Micraspis crocea* which leads to the suppression of rice leaffolder (*Cnaphalocrocis medinalis)* infestation in rice main crop. These findings suggest that incorporating border cropping systems in rice fields can not only enhance the populations of natural enemies, but also lead to increased yields of rice.

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