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Impact of urea and endosulfan on pod damage, gain yield, pest occurrence, abundance of natural enemies and colonization of released predator in the red gram agroecosytem

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Abstract
In the present study, the percentage of pod damage was recorded higher on natural manure applied control plants (24.52) than urea (28.71), endosulfan (30.4) and mixture of both urea and endosulfan treated (23.5) plotted plants. The abundance of natural enemies was greater in natural manure supplied control plants (14.81) whereas it was significantly less in urea (7.31), endosulfan (2.75) and mixture of both urea and endosulfan treated plants (1.40). The highest re-sight of released *Rhynocoris fuscipus* was made in the natural manure treated plots (2.74) whereas a significant gradual decrease or total disappearance of *R. fuscipus* was recorded in the urea (1.37), endosulfan (0.05) and mixture of both urea and endosulfan treated plots (0.00). The estimation of grain yield showed that there was a sharp and steady increase seen in the chemical treated plotted plants compared with control. For instance, the grain yield was 859.41 kg/ha, 778.43 kg/ha, 937.6 kg/ha and 954.7 kg/ha for natural manure, urea, endosulfan and mixture of urea and endosulfan treated plotted plant, respectively; these values were not statistically significant (P=0.001).

Keywords: urea, endosulfan, cow dung manure, natural enemies' abundance, *Rhynocori fuscipus,* colonization, red gram, pod damage, grain yield

1. Introduction

Red gram, *Cajanus cajan* (L.) Millsp. is an important pulse crop in semi-arid tropics and sub-tropical areas of the world [1]. Though majority of people in the developing countries are engaged in agriculture, the productivity is low due to diseases and insect pests [2-3]. For instance, grain legumes, a major food constituent are subjected to attack by many insect pests and diseases [4-6]. High crop yields could be achieved with sustainable agriculture if plants are protected from diseases and insect pests [7]. The tendency has been to rely heavily on chemicals for control of diseases and insect pests [8]. This is because fungicides and insecticides are considered to be reliable due to their quick, effective action [9-10]. Various chemicals have been evaluated and reported to be effective against major crop diseases and insect pests [11]. To increase crop growth and yield, application of chemical fertilizers as the source of nitrogen are involved in any modern agronomic practices [12]. In one hand by adding fertilizers to crop, directly enhance the nutrient availability to the plants but indirectly alter the macro-fauna which habitat on the soil [13-14]. On the other hand, insecticides are the primary tool used to manage insect pest infestations in crop which may change the properties of soil that would affect the non-target natural enemies like reduviid and other predatory insects [15-16]. One ecologically based strategy to address pest problems is to promote earlier or greater colonization by natural enemies through specific habitat management techniques [17-18]. Several such strategies have been proposed, but little research has been directed at the explicit process of natural enemy colonization and the behaviour of predators or parasitoids after entering a new habitat [19]. By conserving locally available predatory Heteroptera, it is possible to ascertain how they disrupt the stability of the pest to help in enhancing pest control [20-21]. Adapting cropping practices, which favours colonization released reduviid predators would improve the action of biological control agents [22]. Keeping this in view, the present study was undertaken to evaluate certain chemical insecticides fertilizers impacts on the abundance of natural enemies and colonization abilities of a released biological control agent, *Rhynocoris fuscipus* (Fabricius)

(Insecta: Heteroptera: Reduviidae).

2. Materials and Methods

An experiment was conducted during Kharif in the red gram cropping fields (cv. ICPL 85063: lakshmi) by designing randomized experimental plots at Allangulam village, Trinunelveli (8° 44' 0" N, 77.42' 0.0" E). Four different fields were selected each measuring 0.2 h at a distance of 100m from one another. A control field treated with natural manure (cow dung decompose), and three treatment plot fields treated with a chemical fertilizer (urea), an insecticide (endosulfan 35 EC @245 g a.i/ha), mixture of both urea and endosulfan respectively along with cow dung. The insecticide spray was initiated at pod initiation stage with the help of knapsack sprayer. Subsequently, the fertiliser was through into the plots by hand. Insect sampling were made per meter square for the infestation of serious pests such as pod borer *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae), brown bugs *Clavigralla gibbosa* Spinola, *Riptortus clavatus* (Hemiptera: Coreidae) and *Maruca testulalis* (Geyer) (Lepidoptera: Pyralidae). Simultaneously, natural enemies of these pest such as predatory insects **(**Mantids, Pentatomids, Geocorids, Anthocorids, Coccinellids, Syriphids, Cocinellids, Reduviids) and parasitoids (dipterans and hymenopterans wasps) were counted for estimating their abundance in the treatment and control field. In addition, an attempt of augmentative release of a potential natural enemy of insect pests, *Rhynocoris fuscipes* was made to study their colonization in red gram habitat, where *H armigera, M. testulalis, R. clavatus* and *C. gibbosa* were found as serious insect pests. The predaceous insect, *R. fuscipes,* was collected from the same locality and reared in the laboratory and the 2nd generation individuals were used for augmentative release. A total of 1200 third or fourth nymphal stages of *R. fuscipes* were released from the mass-reared culture from Entomology Research Unit, St. Xavier's College, Palayamkottai. Observations were made on five tagged plants selected at random from each plot to count densities of pest occurrence, abundance of natural enemies and the status of released predator, *R. fuscipes*. The impacts were evaluated by using an ANOVA to compare the results in the control and treatment plot fields.

3. Results and Discussion

The result of factorial ANOVA's for the study of varied impacts of chemicals (fertilizer or insecticide) on the colonization of natural enemies are shown in the Table 1.

3.1 Pod Damage: The percentage of pod damage was recorded higher on natural manure applied control plants (24.52) than urea (28.71), endosulfan (30.4) and mixture of both urea and endosulfan treated (23.5) plotted plants (Table 1). Even though greater pod damage was observed in all the treatment plants than control plants; the values among them were not statistically significant (P=0.01). All treatment of inorganic fertilizer an soil insecticides could not reduced significant fruit damage in horticulture as compared to bio-intensive cultivation [23]. Ferro [24] suggested that to implement the pesticide management phase, there must be an established relationship between pest densities and resulting damage so that pesticides are not being applied unnecessarily. Frisibie *et al*. [25] stated that crop can withstand some pest damage; insecticide spray can be avoided until the financial gains were equal to the cost of control. Similarly, Cockfield and Potter [9] reported that natural predation on sod webworm eggs were greatly reduced by an insecticide application. The shift from organic soil management to chemical fertilizers has increased the potential of certain insect pests and damages to cause economic losses [26]. Moreover, Meyer [27] proposed that fertilizers not only affect the amount of damage that plant receives from herbivores but also the ability of plants to recover from herbivores.

3.2 Insect pest occurrence: The occurrence and infestation of pests were much in the cow dung treated plots than the agrochemical treated plots. Of the insecticide and fertilizer treatment did not caused significant (P=0.001) reduction of pest density (Table- 2). However, Rajagobal [23] reported that organic fertilizers (NPK 50 kg/, K 20 kg/h) did not caused significantly lower insect pest population followed by fruit damage as compared with composed cow dung due to its unfriendly nature towards natural enemies. Similarly, Hough-Goldstein and Whalen [28] reported that Colorado potato beetle, *Leptinotarsa decemlineata* (Say) were much higher on insecticide treated plots before and after the predator, *Perillus bioculatus* F. (Hemiptera: Pentatomidae) release. They [28] advocated that if the predator nymphs had reached the adults stage means they ate about twice as many *L. decemlineata* per day

3.3 Abundance of natural enemies: The abundance of natural enemies was greater in natural manure supplied control plants (14.81±3.28) whereas it was significantly less in urea (7.31±3.04), endosulfan (2.75±1.57) and mixture of both urea and endosulfan treated plants (1.40± 0.42) (Table-1). A significantly high occurrence of natural enemies (P=0.001) such as Geocorids (*Geocoris tricolor*), Anthocorids (*Orius tantillus*), Pentatomids (*Andrallus spinidens*), Mirids (*Cyrtorhinus lividipennis*), Reduviids (*Coranus spinscutis, Irantha armipus, R.fuscipu*s) Coccinellids (*Coccinella septempunctata* Linneaus *Menochilus sexmaculatus* Fabricius and *Scymnus* sp.), and Mantids (*Mantis religiosa*) recorded in the natural manure supplied plants in comparison to urea and endosulfan treatment plots (Table-2). Similar type of results were obtained by several investigators [2, 26, 29] in their experiment on pigeonpea and stated that higher natural enemies' abundance and greater species richness of predators and parasitoids distinguished from manure compost from conventional organic fertilizer farming [26]. Moreover, Broadly and Thomas [30] stated that the use of insecticides to manage the pests devastates natural enemy complexes. Bellows *et al*. [31] reported that the residual effects of insecticides that cause mortality and physiological disorder to population of natural enemies for considerable lengths of time. George and Ambrose [32] reported that endosulfan treated predatory insects, *Rhynocoris marginatus* (Fabricius), attained late maturity and reduction in survival days and showed less performance for reproduction. This could be the reason for the natural enemy disappearance or reduction in the treatment fields. Moreover, plant nutrition can affect parasitoid biology acting indirectly through the host insect [33-34] and may be providing more suitable prey individuals for the natural enemies. The positive impact of natural manure i.e., organic fertilizers on natural enemies may be a contributing factor towards the consistently higher numbers of *R. fuscipus* found in natural manure treated plants. Due to very low number of studies involved in comparing organic and conventional fertilizer effects on natural enemies, conclusions are difficult to arrive [35]

3.4 Colonization of predator: Released predators generally did not move among plots until they reached the fifth instar, once reached adult stage, they left plots. More number of released *R. fuscipus* was found colonized in the natural manure control plots than in the urea, endosulfan and mixture of urea and endosulfan treated fields (Table-1). The highest re-sight of released *R.fuscipus* was made in the natural manure treated plots (2.74) whereas a significant gradual decrease or total disappearance of *R. fuscipus* was recorded in the urea (1.37), endosulfan (0.05) and mixture of both urea and endosulfan treated plots (0.00). The main biological and behavioural characters that describe a successful predator was populations of that predator must be in synchrony with host population [36]. George and Ambrose [37] reported that post embryonic development will not be proper in insecticide treatment condition. Natural enemies starve or emigrate following sprays that eliminate hosts, hence reducing natural enemy populations under selective pressure [38]. However, Hough-Goldstein and Whalen [28] found that systemic soil insecticides caused significant mortality to the predator, *P.bioculatus* nymphs on treated plots.

3.5 Grain yield: The estimation of grain yield showed that there was a sharp and steady increase seen in the chemical treated plotted plants compared with control. For instance, the grain yield was 859.41 kg/ha, 778.43 kg/ha, 937.6 kg/ha and 954.7 kg/ha for natural manure, urea, endosulfan and mixture of urea and endosulfan treated plotted plant, respectively; these values were not statistically significant (P=0.001) (Table-1). The use of synthetic chemical fertilizers does not result in higher yields, and cow dung manure treatment yield higher, also rated average to above average Therefore, yields obtained here using organic methods compared favorably against reported yields [39]. Similarly, Legaspi, *et al.* [40] reported that Organic farming methods by using poultry manure, for hot peppers can be profitable for growers in Florida provided insect pests remain below economic threshold levels. Ferro and Romoser [36] reported that some plants have the ability to repair injury or grow to produce adequate yields despite supporting pest numbers capable of causing losses in susceptible cultivate. Although, pod and seed yield losses caused by the pod borers and pod-sucking bugs are rather devastating, little work has been conducted regarding pod loss due to pod borers and other pod feeding insect pests. But greater attention has been paid to seed yield losses in most grain legumes [35]. During this study period, pesticide trials observation showed that significant differences occurred between damaged pods on treated plots and untreated plots (P=0.001). The difference in pod damage is worth highlighting because damaged pods may not produce seeds or if and even the seeds are produced these may be of low quality and sometimes may not be viable [41]. Thus, the pesticides used provided a good protection cover against pods infestations by the pod borers paving way for better seed yield. However, Legaspi, *et al* [40] indicated that hot peppers may be grown in Florida without using insecticides when insect pests do not reach economic injury levels and reported that the presence of natural enemies throughout the cropping season may have suppressed the pest populations.

Table 1: Impacts of chemicals (urea and endosulfan) to pod damage, pest occurrence, abundance of natural enemies and colonization of released predator in the red gram agroceosystem

	Natural manure (cow dung)	Urea	Endosulfan (0.07%)	Mixture (Urea/ Endosulfan)
Pod damage (%)	24.52± 7.23a	28.71±6.95a	30.4± 8.13a	23.5±5.98a
Occurrence of natural enemies (no/m^2)	14.81±3.28a	7.31± 3.04b	2.75±1.57c	1.40± 0.42c
Colonization of released predators (no/m^2)	2.74± 1.02a	1.37± 0.45b	0.50±0.21c	0.00±0.00c
Grain yield (Kg/ha)	859.41± 122.47a	778.43± 84.32a	937.6± 107.67a	954.7± 143.93a

Similar alphabets followed the values column are not significant (DMRT 0.05%).

Table 2: Impacts of urea and Endosulfan on the occurrence of insect pests and abundance of natural enemies (no/m^2) in the red gram plots.

Occurrence of pests/ Abundance of natural enemies (no/m^2)	**Natural manure**	**Urea**	**Endosulfan (0.07%)**	**Mixture (Urea/ Endosulfan)**
Insect Pests				
Helicoverpa armigera	7.32±1.32	6.34±1.08	6.63±1.54	6.03±1.27
Claviralla gibbosa	26.3±3.17	22.8±2.75	23.7±3.42	21.5±3.60
Riptortus claviatis	4.79±0.47	3.78±0.73	4.12±0.94	3.56±51
Maruca testulalis	3.45±0.65	3.07±0.79	3.61±0.61	3.05±1.14
Predatory Insects				
Mantids	1.56±0.17a	1.23±0.25a	1.54±0.46a	1.03±0.50a
Pentatomids	0.27±0.44b	0.14±0.07a	0.12±0.09a	0.00±0.00
Geocorids	1.40±0.21c	0.72±0.42b	0.64±0.29b	0.24±009a
Anthocorids	0.32±0.22b	0.34±0.09a	0.21±0.07a	0.11±0.06a
Coccinellids	3.71±0.93a	2.51±0.57a	2.32±1.40a	2.04±1.01a
Syriphids	1.42±0.71b	1.08±0.34a	0.87±0.33a	0.69±0.27a
Reduviids	0.49±033b	0.36±0.12a	0.20±0.08a	0.00±0.00
Mirids	1.81±0.24c	1.07±0.11b	1.14±0.78b	0.45±0.32a
Parasitoids				
Hymenopteans (wasp)	1.03±0.27b	0.54±0.20a	0.73±0.41a	0.43±0.18a
Dipterans (Tachnids)	1.87±0.69b	0.92±0.32a	0.98±0.36a	0.60±0.25a

Similar alphabets followed the values column are not significant (DMRT 0.05%).

4. Conclusion
Chemical fertilizers have increased the potential of certain insects to cause economic losses. Soils with high organic matter exhibit good soil fertility as well as complex food webs and beneficial organisms that prevent infection. Natural chemical present in many plant hosts or produced by micro-

organisms associated with plant that directs the insects toward suitable sites for instance, chemical fertilizer somehow alter this phenomenon. Insecticides applied for the control of pests may also affect beneficial species. Several chemical fertilizers have been found that are reasonably effective in reselling insect pest from feeding: those would somehow block the natural enemies' colonization. Our results were contributed to confirm the similar conclusions, which are soil fertility management, could have several effects on plant quality, which in turn, can affect insect abundance and subsequent levels of herbivore damage. Release of *R. fuscipes* successfully reduced red gram pest and pod damage in these trials and the insecticide was found to be innocuous to the predator. Unfortunately, natural enemies develop resistance slower than pests. There were two well accepted theories about this subject. Pests were pre-adapted to detoxify pesticides because they detoxify plant toxins, whereas natural enemies were not pre-adapted. If a large number of predators can be made available to growers at a reasonable cost, inundative release of *R. fuscipes* may prove to be a useful tool for further red gram pest management programme.

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