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Ecological Engineering Cropping Methods for Enhancing Predator, *Cyrtorhinus lividipennis* (Reuter) and Suppression of Planthopper, *Nilaparvata lugens* (Stal) in Rice- Effect of intercropping system

K Chandrasekar, N Muthukrishnan and RP Soundararajan

Abstract
Three aroma and non aroma crops were raised separately as inter crops in and around rice field (*var*. CO 51) to enhance the activity of predatory mirid bugs *Cyrtorhinus lividipennis* (Reuter) and to mitigate brown planthopper (BPH) *Nilaparvata lugens* (Stal). Aroma varieties *viz*., Pusa Basmati-1, Pusa Suganth and Jeeraga Samba non-aroma varieties *viz.*, BPT 5204, ADT 36 and ADT 43 were used as border crops. The attraction of *C. lividipennis* towards different leaf and flower sample of inter crops were studied through eight- armed olfactometer under laboratory assays. The mean population of mirid bugs and BPH on rice crop varied from 1.94 to 5.04 and 1.43 to 2.57 nymphs and adults per hill due to inter crops. Rice + Pusa Basmati 1inter cropping system significantly influenced for the maximum population of *C. lividipennis* on rice main crop (4.20/hill) and intercrop (5.04/hill) along with highest occurrence ratio (1.2), the BPH population of main crop(1.43/tiller) and inter crop (2.57/tiller) and more CB ratio (1:1.53). This was followed by Rice+ Jeeraga Samba, Rice + Pusa Suganth and Rice + BPT 5204 inter cropping systems that effected for the mean population of main crop (4.32, 3.82 and 3.18) and inter crop (4.65, 4.68 and 3.22) mirid bugs per hill on rice respectively. Rice + ADT 43 inter cropping system however caused for the population of 2.37 mirid bugs per hill on rice when compared to the mirid population of 1.51 per hill on rice alone. Similarly, populations of mirid bugs on inter crops ranged from 1.94 to 5.04 per hill. Maximum mirid bug population (5.04/plant) was observed on Rice + Pusa Basmati 1inter crop. This study concluded that Rice + Pusa Basmati-1 and Rice + Pusa Suganth can be used as inter crops in rice ecosystem to enhance the availability of mirid bugs. In olfactometer studies, mirid bug attraction was higher towards sunflower leaf (3.00) and flower (4.06).

Keywords: Ecological engineering, Pest management, Aroma and Non Aroma, inter cropping system, *N. lugens, C. lividipennis*, Olfactometer

Introduction

Rice (*Oryza sativa* L.) is the principal staple food for more than one third of the world population. Over 90 per cent of the rice is produced and consumed in Asia and 40 to 46 per cent of all irrigated cropland in Asia dedicated to rice production (IRRI, 2013) [9]. As the world human population continues to grow and the availability of agricultural lands decline, estimates are that the world must produce an additional 115 million tons of rice by 2035 to meet increasing global demands and it is responsible for driving science and policy around rice production since the beginning of the new millennium, particularly in Asia (Bouman, 2015) [4]. Several decades of agricultural intensification and over use of insecticides have resulted in a depletion of natural enemy populations, as well as the development of pest populations that are increasingly resistant to insecticides and more virulent against rice varieties (Horgan *et al.*, 2016) [7]. Furthermore, agricultural lands at a global scale have become depleted of functionally important species such as pollinators (Potts *et al.,* 2010) [16] and predatory amphibians (Collins and Crump, 2009) [6]. Rice fields, particularly in the tropics, have a higher diversity of natural enemies than herbivores, resulting in complex food webs (Cohen *et al.*, 1994) [5]. High complexity in food web interactions was predicted to increase the stability and resilience of rice ecosystems (Ings *et al.,* 2009) [8]. Ecological engineering approaches aim to explore habitat manipulation (crop-crop, weed-crop assemblage and polycultures), and provision of resources (mostly natural) in crop ecosystem mainly to conserve and enhance the fitness and efficiency of natural enemies on crop pests, and to completely avoid using synthetic insecticides. Habitat manipulation and provision of natural resources significantly increase the biodiversity of beneficial arthropods of crop pests and thereby reducing the intensity of insecticide use.

These practices will increase biodiversity in the ecosystem, significantly increase biological control of crop pests and provide biological stability in the ecosystem (Mitsch and Jorgensen, 2003) [14].

Materials and Methods

Study site and experimental design

The present investigation was conducted at Krish Vigyan Kendra (KVK), Needamangalam, Thiruvarur during November to January, 2015. The experiment was laid in Randomized Block Design with seven treatments and three replications. The field plot size was 6x 4 m^2. Twenty days old seedlings of var. CO-51 from the nursery were transplanted in the main field at spacing of 20 x 20 cm. Aroma varieties such as Pusa Basmati-1, Pusa Suganth and Jeeraga Samba; and non-aroma rice varieties *viz.,* BPT 5204, ADT 36 and ADT 43 were raised as inter crop (5:1) around main rice crop. Normal agronomic practices like fertilizer application, manual manual weeding was carried out as per the crop production recommendation. No chemical pesticides were given throughout the season. For inter crops, all rice crops were sown / planted at that time of transplanting. (Table 1).

Table 1: Crop varieties and time of sowing

S. No	Variety name	Time of Planting
1	Pusa Basmati 1	At the time of main plant transplanting
2	Pusa Suganth	At the time of main plant transplanting
3	Jeeraga Samba	At the time of main plant transplanting
4	BPT 5204	At the time of main plant transplanting
5	ADT 36	At the time of main plant transplanting
6	ADT 43	At the time of main plant transplanting
7	CO 51 (Main crop)	At the time of main plant transplanting

Effects of intercrop on mirid bug and BPH population

Field experiments

Ten plants were selected randomly from each treatments and in situ count was taken during early morning hours at weekly intervals. In rice, total number of mirid bugs was observed from bottom of hills and was expressed as numbers/ hill. Observations were also taken in all the border crops at the same period of time.

Occurrence Ratio

Similarly, by using *in situ* counts, occurrence ratio (OR) of predators and parasitoids as the case aroma rice, non-aroma rice varieties were estimated by using following formula of Muthukrishnan and Dhanasekaran (2014) [15].

$$OR = \frac{\text{Population of natural enemies on aroma rice and non-aroma rice varieties}}{\text{Occurrence of natural enemies on rice crop}}$$

Cost: Benefit Ratios were worked out for all the field experiments, using the formula of Akila Selvaraj and Sundara Babu (1994).

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

Olfactometer Studies

Olfactometer studies were conducted at Department of Agricultural Entomology, TNAU, Coimbatore using Complete Randomized Design (CRD). Ten grams of healthy plant leaves were kept in the arm and were firmly closed with a lid. The inlet of the olfactometer on the top center place was connected to an aquarium pump (220-240 volt

Ac) to release the pressure. Out of eight arms, leaf samples were kept in six arms and two arms were treated as control. Medical air was passed from aquarium pump at the rate of 4 lit/min into the olfactometer. Twenty numbers of mirid bugs (male and female) were released to the olfactometer through a central hole which also served as odour exit hole. Observations were made on the number of predators settled on each arms at 5, 10, 15 and 20 MAR (Minutes After Release) for their host preference. This experiment was replicated four times. Using similar methodology, this experiment was conducted for different flower samples.

Statistical Analysis

The data were collected from all the experiments and mean values were calculated. Numerical values were transformed into square root transformations before subjecting them to statistical analysis (Gomez and Gomez, 1984). Means in RBD analysis were separated by Least Significant Difference test (DMRT).

Results and Discussion

Field studies

The field study results on impact of inter crops on the incidence of BPH and mirid bug revealed that there was significant variation on different border cropping systems. Mean population of *N. lugens* was 5.71 numbers /tiller on pure rice crop (Table 2) when raised without any border crops. Minimum population of *N. lugens* was observed in rice + Pusa Basmati 1 (1.43/ tiller). This was followed by rice + Pusa Suganth (1.71/ tiller) and rice + BPT 5204 (2.87/ tiller). The higher plant hopper population on rice was observed in rice + ADT 43 (4.00/ tiller), rice + ADT 36 (2.87/ tiller).

Mean population of mirid bugs were significantly more (4.32/hill) in rice based border cropping system than rice alone (1.51/hill). Rice inter cropped with Jeeraga Samba recorded the highest number of mirid bugs (4.32/hill) on rice plants. This was followed by rice + Pusa Basmati 1 (4.20/hill) and rice + BPT 5204 (3.82/hill). However rice + BPT 5204, rice + Pusa Suganth and rice + ADT 43 inter cropping systems registered lesser populations of mirid bugs viz.,3.23, 3.18 and 2.37 per hill.

Table 2: Effect of aroma and non aroma as intercropping systems on population of *Cyrtorhinus lividipennis* and *Nilaparvata lugens*

Border cropping system	Mean *N. lugens*population (No./tiller)		Mean *C. lividipennis* population (No./plant)		Occurrence ratio	Yield (Kg/ha)		Cost Benefit ratio
	Main crop	Inter crop	Main crop	Inter crop		Main crop	Inter crop	
Rice + Pusa Basmati 1	1.43 a	2.57 b	4.20 a	5.04 a	1.2	5658	68	1:1.50
Rice + Pusa Suganth	1.71 b	3.43 a	3.18 c	4.68 b	1.5	5532	55	1:1.47
Rice + Jeeraga Samba	1.43 a	2.29 c	4.32 a	4.65 b	1.1	5464	43	1:1.45
Rice + BPT 5204	2.87 c	2.29 c	3.82 b	3.22 c	0.8	5287	37	1:1.40
Rice + ADT 36	2.86 c	2.00 d	3.23 c	2.37 d	0.7	4853	48	1:1.29
Rice + ADT 43	4.00 d	1.43 e	2.37 d	1.94 e	0.8	4848	51	1:1.29
CO 51 alone	5.71 e	-	1.51 e	-	-	4595	-	1:1.22
SED	0.01	0.01	0.02	0.02		-	68	
CD (P = 0.05)	0.03	0.02	0.04	0.04		-	55	

*****Data are mean values of three replications
Figures were transformed by square root transformation and the original values are given
In a columns means followed by same letter(s) are not significantly different (P=0.05) by DMRT

Pusa Basmati 1 inter crop had the highest population of mirid bugs (5.04) followed by Pusa Suganth (4.68) and Jeeraga Samba (4.65). However inter crops viz., BPT 5204 (3.22/hill)), ADT 36 (2.37/hill)) and ADT 43 (1.94/hill)) had the least population. Inter crops viz., Pusa Suganth, Pusa Basmati 1, Jeeraga Samba, BPT 5204, ADT 36 and ADT 43 registered occurrence ratio of 1.5, 1.2, 1.1, 0.8, 0.8 and 0.7 for mirid bugs (Fig 1).

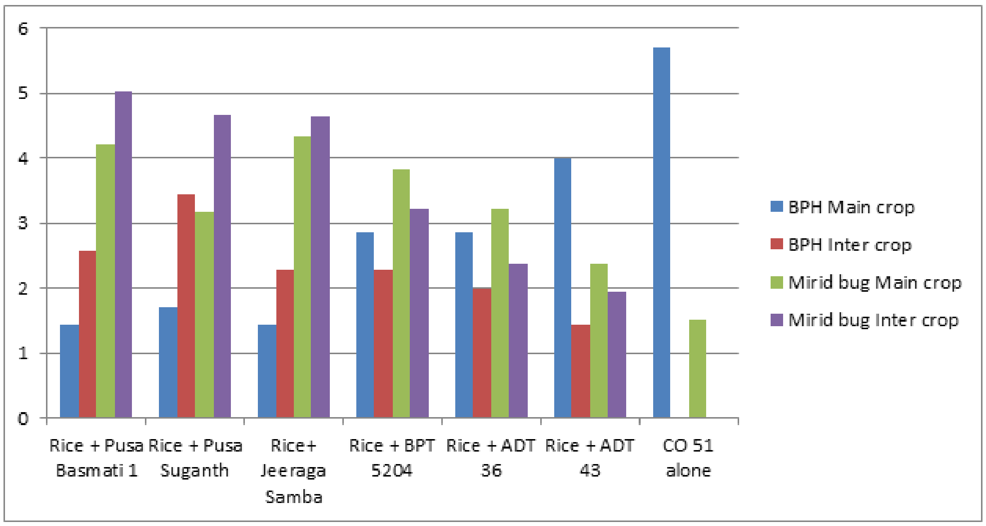

Fig 1: Influence of inter crops on *N. lugens* and *Cyrtorhinus lividipennis* population

Intercropping of aromatic plants significantly reduced pest abundance compared with natural grasses or clean tillage, especially the number of dominant pests that harm.

It is speculated that these results were mainly caused by the repellent effects of aromatic plants. Aromatic plants contain a variety of volatile oils and aromatic properties that may interfere with the ability of a herbivore to locate a host, feed, migrate and breed, and thus prevent herbivore infestation (Lu *et al.*, 2007; Uvah and Coaker 1984; Stan *et al.*, 2003) [13, 19, 17].

Khan *et al*. (2000; 2006) [10, 11] showed that intercropping maize with *Desmodium uncinatum* significantly reduced a stem borer infestation through specific volatiles released by this plant. Basedow *et al.* (2006) [2] found that intercropping *Vicia faba* L. with *Ocimum basilicum* or *Saturela hortensis* significantly reduced the adult population of the sugar beet aphid *Aphis fabae* Scopoli.

Intercropping aromatic plants also had a significant effect on natural enemies. Although the annual cumulative number of natural enemies in plots intercropped with summer savory and ageratum was significantly lower than that of the other cropping regimes, the ratio of natural enemies of pests and the dominant natural enemies hosted by the aromatic plants increased. The results indicated that plots intercropped with summer savory, ageratum and basil were more conducive to the presence of three natural enemies (*Coccinella septempunctata* (L), *Phytoseiulus persimilis* and *Chrysoperla sinica* (Tjeder) (Beizhou, 2011) [3].

Intercropping aromatic plants possibly provides intermediate hosts for natural enemies. The present results showed that the incidence of natural enemies occurred earlier in plots intercropped with aromatic plants. Therefore, natural enemies may effectively control pests at an early stage and reduce the possibility of pest explosion, increasing the biological control role of natural enemies.

Wyss (1996) [20] found that a strip-managed area was colonized by predators and alternative prey in significantly higher numbers than the control. Trenbath (1993) [18] found that, under some conditions, intercropping can contribute to the control of pest populations. Lee *et al*. (2001) [12] found that planting grasses, legumes and perennial flowering plants with corn as refuges may buffer the negative consequences of insecticide application on carabids and increase the activity density of beetles in adjacent fields.

The yield of rice crop was higher in rice + Pusa Basmati 1 inter cropping system (5658 kg/ha) followed by rice + Pusa Suganth (5532 kg/ha) and rice + Jeeraga Samba (5464kg/ha). The remaining inter cropping systems had minimal yield.

Rice alone without inter cropping system recorded the lowest yield (4595kg/ha). The variation in yield may be due to the inter cropping system. In inter cropping system, the population of natural enemies was higher compared to pure rice crop. As the population of natural enemies was higher in inter cropping system, the pest population was decreased and yield variation may occur. The increase in
yield of rice crop as well the yields of inter crops had impact on C:B ratio, which recorded 1:1.50 and 1:1.47 for rice + Pusa Basmati 1 and rice + Pusa Suganth inter cropping system respectively.

Olfactometer studies

Leaf sample

There was significant difference in the attraction of mirid beetle in olfactometer arms due to different leaf and flower samples of border crop. In Olfactometer studies, mirid bug attraction was very high at 5 MAR in Pusa Basmati 1 leaf sample (2.00) followed by Pusa Suganth leaf (1.75). During 10 MAR the attraction of mirid bug population was very high in Pusa Basmati 1 leaf sample (3.00) followed by Pusa Suganth (3.00). Controls had the lowest population (0.50). At 15 and 20 MAR, the mirid bug attraction was high in Pusa Suganth leaf (3.50, 4.00) followed by Pusa Basmati 1leaf sample (3.50, 3.50). At the same time, the controls recorded lowest population (0.75, 0.75). The overall mean population was highly significant in Pusa Suganth leaf sample (3.06) followed by Pusa Basmati 1 (3.00), Jeeraga Samba (2.50) and BPT 5204 leaves (1.63). All the treatments registered significant attraction than in control and each recorded the lowest predator attraction of 0.56 (Table 3).

Table 3: Behavioral bioassay of *Cyrtorhinus lividipennis* against leaf samples of different inter crop in olfactometer

Treatments	No. of *C. lividipennis* (no./arm)*				
	5 MAR	**10 MAR**	**15 MAR**	**20 MAR**	**MEAN**
Pusa Basmati 1	2.00 [a]	3.00 [a]	3.50 [a]	3.50 [b]	3.00 [a]
Pusa Suganth	1.75 [b]	3.00 [a]	3.50 [a]	4.00 [a]	3.06 [a]
Jeeraga Samba	1.75 [b]	2.25 [b]	2.50 [b]	3.50 [b]	2.50 [b]
BPT 5204	1.00 [c]	1.25 [c]	2.00 [c]	2.25 [c]	1.63 [c]
ADT 36	0.50 [d]	1.00 [d]	1.00 [e]	1.00 [e]	0.88 [e]
ADT 43	1.00 [c]	1.00 [d]	1.50 [d]	1.75 [d]	1.31[d]
CO 51	0.25 [e]	0.50 [e]	0.75 [f]	0.75 [f]	0.56 [f]
SEd	0.01	0.01	0.01	0.01	0.01
CD (0.05%)	0.01	0.02	0.02	0.02	0.02

*Mean of 4 replications

** MAR Minutes After Release Figures were transformed by square root transformation and the original values are given in a columns means followed by same letter(s) are not significantly different (P=0.05) by DMRT

Flower sample

Flower samples from the border crops were collected and kept in Olfactometer arms. Number of mirid bugs attracted towards various flower samples is given in Table 4. At 5 MAR, the mirid bug attraction was high in Pusa Basmati 1 (2.75), followed by Pusa Suganth (2.50) and the lowest population was recorded in BPT 5204 flowers (0.00). During 10 MAR, the attraction of mirid bugs was towards Pusa Basmati 1 (3.00) and Pusa Suganth (3.00). At 15 MAR, the attraction was more in Pusa Suganth (4.00) and Pusa Basmati 1 (3.75), and less in control (1.00). At 20 MAR, the attraction was more in Pusa Basmati (4.75) and Pusa Suganth (4.50). The overall mean attraction was recorded high in Pusa Basmati 1 (3.56) followed by Pusa Suganth (3.50), Jeeraga Samba (2.88), BPT 5204 (1.88), ADT 43 (1.06) and ADT 43 (1.00). Zhu *et al.* (2013) reported that, *Sesamum indicum*, *Emilia sonchifolia*, and *Impatiens balsamena* appeared potentially suitable for supporting *Anagrus optabilis* and *Anagrus nilaparvatae* to the extent that adults were attracted to the odours of these flowers.

Table 4: Behavioral bioassay of *Cyrtorhinus lividipennis* against flower samples of different inter crop in olfactometer

Treatments	No. of *C. lividipennis* (no./arm)*				
	5 Mar	**10 Mar**	**15 Mar**	**20 Mar**	**Mean**
Pusa Basmati 1	2.75 [a]	3.00 [a]	3.75 [b]	4.75 [a]	3.56 [a]
Pusa Suganth	2.50 [b]	3.00 [a]	4.00 [a]	4.50 [b]	3.50 [a]
Jeeraga Samba	2.50 [b]	2.50 [b]	3.25 [c]	3.25 [c]	2.88 [b]
BPT 5204	1.25 [c]	1.50 [c]	2.00 [d]	2.75 [d]	1.88 [c]
ADT 36	0.00 [e]	0.75 [e]	1.25 [e]	2.00 [e]	1.00 [e]
ADT 43	0.50 [d]	1.25 [d]	1.25 [e]	1.25 [f]	1.06 [d]
CO 51	0.00 [e]	0.75 [e]	1.00 [f]	0.50 [g]	0.56 [f]
SEd	0.01	0.01	0.01	0.01	0.01
CD (0.05%)	0.02	0.02	0.02	0.02	0.02

*Mean of 4 replications

** MAR Minutes After Release

Figures were transformed by square root transformation and the original values are given

In a columns means followed by same letter(s) are not significantly different (P=0.05) by DMRT

Conclusion

From the above results, Pusa Basmati-1and Pusa Suganth could be recommended for creating flowering strips in the bunds of rice crop. It will increase the predator, *C. lividipennis* which leads to the suppression of rice plant hopper infestation in rice main crop. The aroma rice plants can be sown in the appropriate time to make available the alternate food sources to natural enemies throughout the crop season.

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References

1. Akila S, Sundara Babu PC. Release of different doses of *Trichogramma* and its effect on internode borer, yield and quality of sugarcane. Sugarcane London. 1994; 2:22-23.
2. Basedow T, Hua L, Aggarwal N. The infestation of *Vicia faba* L. (Fabaceae). by Aphis fabae (Scop.) (Homoptera: Aphididae) under the influence of Lamiaceae (*Ocimum basilicum* L. and *Satureja hortensis* L.). J Pest Sci. 2006; 79:149-154.
3. Beizhou S, Zhang J, Hu J, Wu Hongying, Kong Y, Yao Y. Temporal dynamics of the arthropod community in pear orchards intercropped with aromatic plants, 2011. (wileyonlinelibrary.com) DOI 10.1002/ps.2156.
4. Bouman B. Talking Rice at the food security summit, 2015. http://irri.org/index.php.
5. Cohen JE, Schoenly K, Heong KL, Justo H, Arida G, Barrion AT, *et al.* A food web approach to evaluating the effect of insecticide spraying on insect pests population dynamics in a Philippine irrigated rice ecosystem. Journal of Applied Ecology. 1994; 31:747-763.
6. Collins JP, Crump ML. Extinction in our times: Global amphibian decline. Oxford: Oxford University Press, 2009.
7. Horgan, Rama AF, Carmencita C, Bernala J, Villegasa M, Alexander C, *et al*. Applying ecological engineering for sustainable and resilient rice production systems. International Conference of Sabaragamuwa University of Sri Lanka. 2015-2016, (ICSUSL 2015), 7-15.
8. Ings TC, Montoya JM, Bascompte J, Blüthgen N, Brown L, Dormann CF, *et al*. Review: Ecological networks-beyond food webs. Journal of Animal Ecology. 2009; 78:253-269.
9. IRRI. Rice Almanac, Fourth Edition. Los Baños: International Rice Research Institute, 2013.
10. Khan ZR, Pickett JA, Berg JV, Wadhams LJ, Woodcock CM. Exploiting chemical ecology and species diversity: stem borer and striga control for maize and sorghum in Africa. Pest Manag. Sci. 2000; 56:957-962.
11. Khan ZR, Pickett JA, Wadhams LJ, Hassanalia A, Midegaa CAO. Combined control of *Striga hermonthica* and stemborers by maize–*Desmodium* spp. intercrops. Crop Prot. 2006; 25:989-995.
12. Lee BH, Choi WS, Lee SE, Park BS. Fumigant toxicity of essential oils and their constituent compounds towards the rice weevil (*Sitophilus oryzae*), Crop prot. 2001; 20:317-320.
13. Lu W, Hou ML, Wen JH, Li JW. Effects of plant volatiles on herbivorous insects, Plant Prot. 2007; 33:7-11.
14. Mitsch WJ, Jørgensen SE. Ecological engineering: a field whose time has come, Ecological engineering. 2003; 20(5):363-377.
15. Muthukrishnan N, Dhanasekaran V. Management of cotton pink bollworm *Pectinophora gossypiella* (Saunders) through trap cropping system. *In*: Extended Summary book on National Symposium on Emerging Trends in Eco-Friendly Insect Pest Management held at Tamil Nadu Agricultural University, Coimbatore, AE. Publications, Coimbatore, 2014, 326-32.
16. Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE. Global pollinator declines: trends, impacts and drivers. Trends in Ecology and Evolution. 2010; 25:345-353.
17. Stan F, Helen B, Rosemary HC. Companion planting – do aromatic plants disrupt host-plant finding by the cabbage root fly and the onion fly more effectively than non-aromatic plants. Entomol Exp Appl. 2003; 109:183-195.
18. Trenbath BR. Intercropping for the management of pests and diseases. Field Crops Research. 1993; 34:381-405.
19. Uvah III, Coaker TH. Effect of mixed cropping on some insect pests of carrots and onions. Entomol Exp Appl. 1984; 36:159-167.
20. Wyss. The effects of artificial weed strips on diversity and abundance of the arthropod fauna in a Swiss experimental apple orchard. Agriculture, Ecosystems and Environment. 1996; 60:47-59.
21. Zhu P, Gurr GM, Lu Z, Heong KL, Chen G, Zheng X, Yang Y. Laboratory screening supports the selection of sesame (*Sesamum indicum*) to enhance *Anagrus* spp. parasitoids (Hymenoptera: Mymaridae) of rice planthoppers. Biological Control. 2013; 64(1):83-89.