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Research Article

AGRO ECOSYSTEM ANALYSIS AND ECOLOGICAL ENGINEERING BASED PLANT HEALTH MANAGEMENT IN ORGANIC TOMATO (*Lycopersicon esculentum*) CULTIVATION

SREE LATHA E.*, JESU RAJAN S., SWATHI YADAV K. AND SATHISH R.

National Institute of Plant Health Management, Rajendra Nagar, Hyderabad, 500030, Telangana
*Corresponding Author: Email-sreelatha437@gmail.com

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Abstract- Tomato (*Lycopersicon esculentum*) is one of the most important culinary vegetable throughout the world. It is consumed in diverse ways such as raw fruits for salads, side dishes, processed foods like ketchups, soups set. Tomato crop was maintained in Ecological Engineering field at NIPHM, for the purpose of demonstration and training of organic agriculture. Agro Ecosystem Analysis on biological factors with respect to pests and beneficial insects, to understand the intricate interactions in the ecosystem, revealed that the ecosystem has created favourable conditions for natural enemies and pollinators. Natural enemies were controlling tomato pests in the absence of external forces like chemical pesticides. The pest and natural enemy interactions are discussed based on the results.

Key words- Tomato, Organic agriculture, Natural enemies, Ecological engineering, Agro ecosystem analysis, whiteflies

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Introduction

Tomatoes are used for making curries, soup, juice, pickles, jams, ketchup, puree, sauces and in many other ways. It is also used as a salad vegetable where pesticide residue free fruit is essential. Tomato is mainly grown as *Rabi* crop in the plains of India. However, in the hilly region it can also be grown as a summer and rainy season crop so throughout the year it is available [1].

Ecological Engineering field at NIPHM, maintained in the last 4 years for the purpose of demonstration and training of organic agriculture created an ecosystem favourable for beneficial insects. The field being maintained without the use of artificial external inputs such as chemical fertilizers and pesticides achieved sustainable productivity. The techniques like Agro Ecosystem Analysis (AESA) and Ecological Engineering (EE) based Plant Health Management (PHM), restored and maintaining the soil fertility, so the field produces quality products without chemical residues. These are achieved by following below ground and above ground EE, poly culture, crop rotation, recycling of plant residues, proper tillage and water management.

The field was incorporated with organic fertilizers like, Farm Yard Manure (FYM), Vermicompost and biofertilizers, particularly mycorrhiza which plays an important role in improving soil health and uptake of important macro and micronutrients by the crops [2] Biofertilizers like PSB (Phosphate Solubilizing Bacteria) + KSB (Potassium Solubilizing Bacteria) + ZSB (Zinc Solubilizing Bacteria) are added to reduce the reliance on chemical fertilizers. These bio fertilizers supply plant nutrients at optimum levels, which in turn supress development of pests. Addition of excess nutrients to the plants also leads to many problems, for example excess of available nitrogen increases the susceptibility of plants to outbreak of sucking insect pests like aphids, whiteflies etc. Nutrient stress from insufficient plant nutrients can also cause plants to be more susceptible to diseases and insect-pests [3-6].

Careful planning and execution of soil fertility program is an important component of insect pest management. A number of insect pests i.e., about 100 insect and 25 non insect pest species are reported to ravage the tomato fields [7]. *Liriomyza trifolii* damages the plant by extensive leaf mining activity reduces the photosynthetic rate to about 62 per cent within mined tissues as compared with unmined leaves, leads to adverse effects which ultimately reduce the yield [8] fruit borer, *Helicoverpa armigera* which causes damage to tomato resulting in yield loss ranging from 20 to 60 percent [9, 10]

Materials and methods

In ecological engineering fields different biofertilizers and bio pesticides and their mixtures were tested to know their effect on the insect pest damage and the yield. The tomato variety used for the trial was Pusa Ruby. The seed was sown in nursery on 1st November 2016 and transplanted on 1st December 2016. Plot size was six rows of 2 m long i.e. 3.6 x 2 m planted at 60 X 45cm row-to-row and plant-to-plant spacing. Observations were taken from 30 days after transplanting (DAT) at 10 days interval till the final harvest of the crop. The trial was conducted in randomized block design with three replications. Experiment was conducted with 6 treatments. The details of the treatments are given in [Table-1].

Table-1 *Details of treatments used to conduct experiment*

Sl. No	Treatment Number	Details of the treatment
1	T1	Soil treatment- neem cake with biopesticides (*Trichoderma harzianum*) + *Pseudomonas fluroscence*+ *Lecanicilliumlecanii*) + PSB (Phosphate Solubilizing Bacteria) + KSB (Potassium Solubilizing Bacteria) + ZSB (Zinc Solubilizing Bacteria)
2	T2	Soil treatment- (*Trichoderma harzianum* + *Pseudomonas fluroscence*) + PSB+KSB+ZSB
3	T3	Soil treatment- Neem cake + Mychorrhyza + Trichoderma + Vermicompost
4	T4	Soil treatment- Neem cake with biopesticides (Tri. + Pseudo.+Lec.) + PSB+KSB+ZSB + seedling treatment with biofertilizer (PSB +KSB+ZSB)
5	T5	Soil treatment- neem cake with biopesticides (Tri. + Pseudo.+lec.) + PSB+KSB+ZSB, + seedling treatment with biofertilizer (PSB+KSB+ZSB) + Biopesticides (Tricho. + Pseudo.)
6	T6	Control

Ecological Engineering Plants: Attractant plants like sunflower, cosmos, corn and shrubs to attract mirid bugs and lacewings were planted around the field. Repellent plants like Ocimum/Basil are grown to repel gram pod borer and Tobacco caterpillar. Nectar rich plants with small flowers i.e. mustard, sunflower, cowpea, sesame, sun hemp etc., are planted to provide shelter and food to the adults of parasitoids and predators.

Data Collection

Data was collected on major insect pests and beneficial insects that occur in the tomato field. The observations were taken on the sucking insect pests, fruit borer and beneficial insects, which include Aphid (*Myzus persicae*), Serpentine leaf miner (*Liriomyza trifolii*), Whitefly (*Bemisia tabaci*), Fruit borer (*Helicoverpa armigera*), Leaf eating caterpillar (*Spodoptera litura*), Mirid bugs (*Nesidiocoris tenuis*), different lady bird beetles (*Menochilus sp, Coccinella sp, Harmonia sp,*), green lace wing, different species of predatory spiders and pollinators.

Aphid: Five plants were selected and tagged. Population of aphid was recorded through the aphid infestation index. Leaves, flowers and fruits in selected plants were observed and the degree of infestation level was recorded and categorized into grades as 0, 1, 2, 3 and 4 according to visual and inspection counts. The aphid index is shown in [Table-2].

Whitefly: Five plants were randomly selected and tagged. Three leaves from top, middle and lower portion of each plant of 5 tagged plants were observed for the presence of nymphs and adults of whitefly.

Leaf Miner: Five plants were randomly selected and tagged from each plot. Tagged plant was observed entirely for presence of leaf miners. The total number of mined leaves is noted and calculated % mined leaves per total leaves.

Mirid Bugs: Five plants were randomly selected and tagged. Total number of nymphs and adults were counted from three leaves from upper, one from middle and one from lower third of plant.

Coccinellids: Five plants were randomly selected and tagged. Total number of grubs and adults of coccinellids of different species present on each plant were counted.

Table-2 *Aphid infestation index*

Grade	Aphid index
0	No population of aphid on plant
1	One or two aphids observed on plant but no colony formation
2	Small colony of aphids observed with countable numbers on plant but no damage symptoms seen
3	Big colony of aphids is observed on plant and aphids can be counted and damage symptoms seen
4	Big colony of aphids observed on plant and aphids could not be counted and severe damage symptoms seen and plant withered

Statistical Analysis: All the parameters were analysed using one way ANOVA in randomized block design.

Table-3 *Mean population of insect pests and natural enemies during vegetative and flowering stage in tomato Rabi 2016-17,NIPHM, Rajendranagar.*

Treatment	30DAT					40 DAT						50 DAT					60 DAT			
	WF	APH	LM	MB	SP	WF	APH	LM	MB	COC	SP	WF	LM	MB	COC	SP	WF	LM	MB	SP
T1	1.00	0.40	3.00	0.07	0.00	0.53	0.87	0.13	1.00	0.07	0.07	0.60	0.13	0.33	0.13	0.00	0.67	4.53	0.13	0.07
T2	0.80	0.00	0.60	0.20	0.00	0.33	0.20	0.00	1.33	0.07	0.13	0.53	0.00	0.07	0.07	0.13	0.00	5.67	0.00	0.07
T3	0.60	0.40	1.00	0.00	0.07	0.27	0.20	0.13	1.33	0.07	0.13	0.53	0.13	0.07	0.07	0.00	0.20	7.13	0.20	0.07
T4	1.53	0.60	0.73	0.00	0.07	0.93	0.00	0.13	1.80	0.00	0.13	0.87	0.13	0.13	0.00	0.00	0.20	4.67	0.00	0.00
T5	0.60	0.33	0.53	0.47	0.07	1.00	0.00	0.00	1.53	0.07	0.00	0.13	0.00	0.00	0.07	0.00	0.27	4.20	0.07	0.00
T6	0.73	0.00	1.53	0.13	0.00	0.53	0.00	0.07	1.73	0.07	0.07	1.00	0.07	0.20	0.07	0.00	0.27	7.93	0.13	0.07
Total	7.00	9.13	8.27	1.07	3.80	4.87	1.73	9.20	9.07	0.87	4.20	4.13	1.27	1.20	0.53	1.73	35.73	34.67	0.80	0.27
Mean	0.88	0.29	1.23	0.14	0.03	0.60	0.21	0.08	1.46	0.06	0.09	0.61	0.08	0.13	0.07	0.02	0.27	5.69	0.09	0.04
F (Prob.)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-4 *Mean population of insect pests and natural enemies during fruiting stage in tomato Rabi 2016-17, NIPHM, Rajendranagar.*

Treatment	70 DAT				80 DAT					90 DAT				100 DAT		
	WF	LM	MB	COC	WF	LM	MB	COC	SP	WF	LM	COC	SP	WF	LM	COC
T1	0.47	8.33	0.07	0.00	0.60	0.07	0.27	0.13	0.13	0.27	11.87	0.07	0.00	0.07	0.33	0.00
T2	0.27	8.40	0.13	0.00	0.67	0.13	0.13	0.07	0.00	0.13	10.07	0.00	0.07	0.13	0.27	0.07
T3	0.20	10.67	0.07	0.07	0.33	0.07	0.33	0.00	0.00	0.13	13.67	0.07	0.00	0.13	0.53	0.07
T4	0.60	7.40	0.00	0.00	0.60	0.27	0.13	0.00	0.07	0.60	9.87	0.00	0.00	0.13	0.33	0.07
T5	0.00	5.47	0.07	0.07	0.20	0.00	0.27	0.00	0.00	0.00	7.20	0.00	0.13	0.13	0.13	0.00
T6	0.27	6.40	0.20	0.00	0.33	0.13	0.20	0.00	0.00	0.47	9.73	0.13	0.00	0.00	0.67	0.00
Total	48.48	47.21	0.68	2.87	3.40	2.00	1.53	0.40	1.80	64.01	62.68	0.47	0.79	2.85	2.47	0.21
Mean	0.30	7.78	0.09	0.02	0.46	0.11	0.22	0.03	0.03	0.27	10.40	0.05	0.03	0.10	0.38	0.04
F (Prob.)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Results

The differences in population of different insect pests and natural enemies were found to be non-significant among different treatments [Table-3 and 4]. It indicated that the pest population and the natural enemies' population were found to be homogenous in all the treatments. It indicates that in organic farming, irrespective of the bio fertilizers used all the treatments are behaving uniformly with respect to pest natural and enemy interactions.

However, the data presented in the [Fig-1] indicates that there is decrease in the aphid population with the increase in coccinellid population. Aphid population observed at 30 DAT was at peak with 1.70 aphid index. The population of coccinellids at 30 DAT was zero. The population of coccinellids gradually increased and reached a peak stage at 50 DAT while the population of aphids decreased gradually with the increase in coccinellid population. The population of aphids reached to zero aphid indexes by 50 DAT and thereafter did not increase throughout the crop season. This indicates that with the increase in the coccinellid population the aphid population was completely supressed. The population of coccinellids was still present in the field continuously till the last picking maybe by feeding on the other sap sucking insects like whiteflies and some borer eggs.

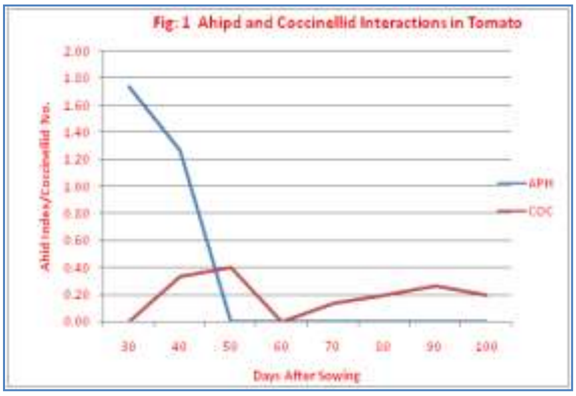

Fig-1 Ahipd and Coccinellid Interactions in Tomato

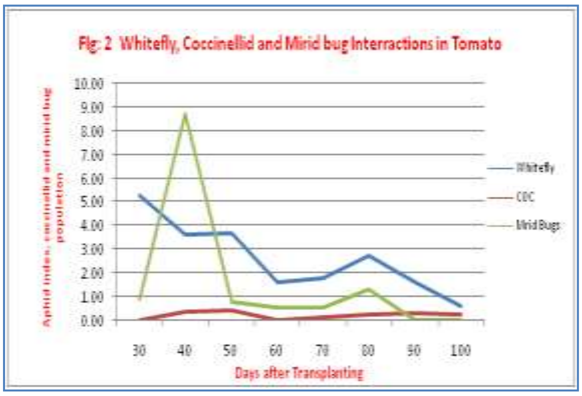

Fig-2 Whitefly, Coccinellid and Mirid bug Interactions in Tomato

The data presented in the [Fig-2] reveals that there is a relation between the population of whiteflies and mirid bugs. The population of whiteflies at 30 DAT was at its peak level with 5 whiteflies/leaf. The population of mirid bugs at 30 DAT was 1.07 which reached its peak stage at 40 DAT. The data reveals that the mirid bug population was able to effectively control the whitefly population in absence of the external forces like chemicals. The results are in line with [11] who stated that *Nesidiocoris tenuis* was highly effective in controlling *B. tabaci* on tomato under experimental conditions. It is also observed that at 90 DAT the population of Mirid bugs reached zero. The mirid bugs were reared on whiteflies in the laboratory and confirmed their feeding ability on whiteflies.

Fruit borer (*Helicoverpa armigera*) was not observed during any time of the crop within the season. Leaf eating caterpillar (*Spodoptera litura*) was also not observed in any season during the crop period.

Discussion

Ecological engineering for pest management is a human activity that modifies the environment and involves experimentation to identify from among a number of agronomically feasible options [12]. The cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops [13]. Enhancement of biodiversity by using different flowering plants in and around the field will increase number of parasitoids and predatory natural enemies due to availability of nectar, pollen etc. from the flowering plants. The major predators are a wide variety of spiders, lady bird beetles, long horned grasshoppers, chrysoperla, earwigs [14]. The antagonist *T. harzianum* is chosen to be the most promising bio-control agent for management of tomato wilt caused by *F. oxysporum f. sp. lycopersici*. [15]. The bacteria *Pseudomonas fluorescens* is able to control root Knot disease on Tomato caused by *Meloidogyne javanica* nematode when used as root dipping, soil drench as well as seed treatment [16]. The entomopathogenic fungi *Lecanicillium lecanii* can be used as a promising agent in pest control and integrated pest management programs for whitefly [17]. Fungal diseases and nematodes were not appeared during the entire season. Beneficial Insects: Honeybees like *Apisflorea* (Fabricius, 1787), *Apiscerana indica* (Fabricius, 1793), *Apis mellifera* (Linnaeus, 1758) and *Apisdorsata* (Fabricius, 1793) and other pollinators like *Nomia*sp., *Xylocopa, Pseudapis*ect., were found on ecological engineering flowering plants like sunflower planted around the field hence conserving the precious biodiversity by providing food and shelter to these pollinators. The present study corroborated with the findings of [18] who noticed more abundance of Apis sp. in sunflower ecosystem. Bees have the potential to seriously reduce floral nectar levels for parasitoids[19], but they may also increase the accessibility of nectaries by 'tripping' flowers [20]. Mirid Bugs are also considered a pest because it can feed on tomato plants, causing necrotic rings on stems and flowers and punctures in fruits [11] but, no such symptoms were observed in the field and their feeding on whiteflies was confirmed with laboratory experiments. Predators like lady bird beetles, *Coccinella septempunctata* and *Menochilus sexmaculata* are recognized as one of the important regulating factors in managing the aphid population. They also feed on mites, whiteflies, small eggs of insects [21].

Over the past two decades many investigators recorded the decline in population of bee species and the colony numbers (colony collapse disorder) due to the environmental problems like climate change, drought, fire, deforestation, pesticides, cell phones and many other reasons. Crop Pollination Exposes Honey Bees to pesticides which alter their susceptibility to the gut pathogen *Nosema ceranae* which leads to the decline in honey bee population [22]. Honey bees are so important to both agriculture and economics so efforts are important to reduce this declination.

Conclusion

From the present study, it can be concluded that the differences in population of major insect pests and natural enemies of tomato were found to be non-significant among different treatments of biofertilizers and biopesticides in an ecological engineering field. It is also found that the field was free from infestation of fruit borer and leaf eating caterpillars completely throughout the crop season. Organic farming with Ecological Engineering can conserve many beneficial organisms to promise sustainable agriculture.

Application of research: This research was done with an aim to know the efficacy of different bio fertilizers and bio pesticides in an ecological engineering field. This research mainly orients towards the sustainable agriculture by using ecological engineering and Agro Ecosystem Analysis procedure and to know how the population of pest complex will vary in the crops in ecological engineering field.

Research Category: Ecological Engineering, Agro Ecosystem analysis, Biofertilizers and Biopesticides

Abbreviations:
DAT: days after transplanting

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References

[1] http://agritech.tnau.ac.in/horticulture/horti_vegetables_tomato.html
[2] http://niphm.gov.in
[3] Krauss A. (1969) *Journal of Plant Nutrition and Soil Science*, 124: 129-147
[4] Graham R.D. (1983) *Advances in Botanical Research*, 10 , 221-276.
[5] Perrenoud S. (1990) *Potassium and plant health. IPI Research Topics No. 3, 2 nd rev. edition. Basel/Switzerland.*
[6] Marschner H. (1995) *Mineral nutrition of higher plants. 2nd ed., Academic Press,* pp. 436-460.
[7] Lange W.H and Bronson L. (1981) *Annual Review of Entomology*, 26, 345-371.
[8] Johnson M.W., Welter S.C., Toscano N.C., Ting I.P. and Trumble J.T. (1983) *Journal of Economic Entomology*, 76, 1061 – 1063.
[9] Tewari G.C. and Krishnamoorthy P.N. (1984) *Indian Journal of Agricultural Sciences*, 54, 341-343.
[10] Lal O.P. and Lal S.K. (1996) *Journal of Entomological Research*, 20 (4), 355-364.
[11] Javier Calvo, Karel Bolckmans, Philip A. Stansly and Alberto Urbaneja (2009) *Bio Control*, (54), 237-246
[12] Zhu P, Lu Z, Heong K, Chen G, Zheng X, et al. (2014) *PLoS ONE* 9(9), e108669.
[13] Gurr G. M., Wratten S. D. and Altieri M. A. (2004) *CSIRO Publishing, Collingwood, Australia*. 244 pp., ISBN 0 643 099022 3.
[14] Shankar G., Sharma O.P., Dhana Raj Boina and Richa Varshney (2014) *AESA Based IPM package No. 18. AESA based IPM-Tomato, NIPHM*. P.No. 22
[15] Barari H. (2016) *Agronomical Research in Moldavia*, 49(1), 91-98.
[16] Fakhreldin Musa Eltom Eltayeb (2017) *International Journal of Current Microbiology and Applied Sciences*, 6 (6), 1176-1182
[17] Al-Shuraym and Laila A. (2017) *International Journal of Chem Tech Research*, 10 (5), 527-534
[18] Amit J., Sreedevi K. and Rajendra Prasad (2010) *Current Biotica*, 5 (3), 344-350.
[19] Lee J.C. and Heimpel G.E. (2003) In Proceedings of the 1st International Symposium on Biological Control of Arthropods (R.G. Van Driesche, ed.), pp. 220–225. United States, Dept of Agriculture, Forest Service, Morgantown, WV, FTET–(2003)–05.
[20] Gurr G.M., Wratten S.D., Tylianakis J., Kean J. and Keller M. (2004) In Plant-derived Food and Plant–carnivore Mutualism (F.L. Wäckers, P.C.J. van Rijn and J. Bruin, eds), Cambridge University Press, Cambridge. In press
[21] Singh Yajuvendra. Aastik Jha. Savita Verma. Mishra V. K. and Singh S. S. (2013) *African Journal of Agricultural Research*, 8 (28), 3814-3819.
[22] Pettis J.S., Lichtenberg E.M., Andree M., Stitzinger J., Rose R., *et al.* (2013) *PLoS ONE,* 8 (7), e70182.