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Role of entomophage biodiversity park in Bidi tobacco based agro-ecosystem

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Abstract
The experiment was carried out in tobacco based agro-ecosystem. The entomophage biodiversity park along with two separate plots of tobacco near and away were raised at Bidi Tobacco Research Station, Anand Agricultural University, Anand during the year 2018. Tobacco being long duration crop passes through biotic and abiotic stresses. Among these biotic stress insect pest causes economic losses both quantitatively and qualitatively. Chemical control of these pests has certain important limitations like pesticide residues. The activity of various natural enemies like spider, coccinellids, *Nesidiocoris tenuis*, *Geocoris ochropeterus* and *Rhynocoris* sp, were found on different crops raised under entomophage park. Out of various bio agents maximum activity of *N. tenuis* was found in tobacco. The population of coccinellids were build up in flowering crops like marigold, cotton, and maize. The population of spiders were present in all the crops raised under biodiversity perk. The abundance of natural enemies and insect pests on tobacco grown nearby entmophage biodiversity park and away from it revealed more or less similar trend throughout the crop season. Coccinellids had highly significant negative correlation with Bright sun shine hours (BSS), Wind speed (WS), Minimum temperature (Min T), Mean Temperature (Mean T), Relative humidity morning (RH_1), Relative humidity evening (RH_2), Mean relative humidity (Mean RH), Vapor pressure morning (VP_1), Vapor pressure evening (VP_2) and Mean vapor pressure (Mean VP). Among the predatory bugs, *Geocoris ochropeterus* showed significant negative correlation with Wind speed (WS), Relative humidity evening (RH_2) and Mean relative humidity (Mean RH), while *Nesidiocoris tenuis* established highly significant negative correlation with Bright sun shine hours (BSS), Minimum temperature (Min T), Mean Temperature (Mean T), Relative humidity morning (RH_1), Relative humidity morning (RH_2), Mean relative humidity (Mean RH), Vapour pressure morning (VP_1), Vapour pressure evening (VP_2) and Mean vapor pressure (Mean VP). Entomophage biodiversity park suggestively boosted the fecundity and survival of the natural enemies of the crop pest and such parks may play an imperative role in maintaining the biodiversity and augment natural enemies leading to natural pest control.

Keywords: Entomophage park**,** natural enemy, *Nesidiocoris tenuis*, tobacco

Introduction
India has a prominent place in the production of tobacco and stands second in area while third in production of tobacco in the world. Tobacco (*Nicotiana tabacum* L.) is one of the important commercial crops grown in about 4.5 lakh ha which is about 0.23% of cultivated land in India. About 13 states in the country grow tobacco, among them, Andhra Pradesh, Gujarat, Uttar Pradesh and Karnataka are major tobacco growing states [1]. Tobacco being long period crop passes to biotic and abiotic stresses. Among these biotic stresses insect pest causes economic losses both quantitatively and qualitatively. Synthetic control by chemical insecticides of these pests has certain significant restrictions like pesticide residues. Hence there is need to rationalize pest control practices taking full advantage of biotic agents [2]. Biotic stress can be defined as a stress that is cause in plants due to damage instigated by insect, fungi, nematodes, bacteria, viruses, vertebrate pests, parasites, weeds and other cultivated plants [3]. Integrated pest management is an important ecosystem service that can be enhanced by increasing plant diversity [4]. Tobacco based agro- ecosystem and its biotic elements, which subsequently facilitate development of techniques to conserve and utilize the indigenous natural enemies of tobacco pests [5]. To define Entomophage parks is an areas free from pesticide applications set aside for the purpose of protecting populations of natural enemies [6]. With view to restore and conservation of natural enemies for insect pest an entomophage biodiversity park was raised in tobacco based agro ecosystem.

2. Material and Methods

The entomophage biodiversity park was raised in the middle of tobacco based agro ecosystem in field on second week of August 2018 at Bidi Tobacco Research Station, Anand Agricultural University Anand (Gujarat). Five lines 5 m. length and 0.90 m. apart from each other were sown / transplanted with each of the seven different crops *viz* tobacco, marigold, sena, cotton, kuvadio (*Cassia* sp.), maize and lucerne in a following sequence, or given in the layout.

Field Layout

T o b a c c o	M a r i g o l d	S e n a	C o t t o n	K u v a d i o	M a i z e	L u c e r n	M a i z e	K u v a d i o	C o t t o n	S e n a	M a r i g o l d	T o b a c c o

The area under entomophage biodiversity park was maintained in the field throughout the crop season kept free from spraying of any insecticides. Moreover, two separate plots of 9m X 7.5m near and away from the park with tobacco as sole crop raise at Bidi Tobacco Research Station, Unit 8, Anand Agricultural University, Anand conducted in the year 2018. The data on observations for insect pest and natural enemies was taken from entomophage park and tobacco plots rose near and away from at weekly interval. The data was analyzed as per suggested by Steel and Torrie (1960) [7].

3. Results and Discussion

The data presented in Table 1 reveal the activity of various natural enemies like spider, coccinellids, *Nesidiocoris tenuis*, *Geocoris ochropterus* and *Rhynocoris* sp, were found on different crops raised under entomophage park. Out of various bio agents maximum activity of *N. tenuis* was found in tobacco. The activity of spider was found in tobacco, marigold, sena, cotton, kuvadio, maize and lucern. The population of coccinellids were build up in flowering crops like marigold, cotton, and maize. This result indicated that natural enemies of insect pest sheltered, sustained and multiply in entomophage biodiversity park.

Gupta *et al.*, (2012) [6] reported that the entomophage park suggestively boosted the fecundity and survival of the natural enemies of the crop pest and such parks may play an important role in maintaining the biodiversity of natural enemies and enhancing natural pest control. Nectar-providing species increased the abundance of the natural enemy [8]. The use of flowers in agroecosystems for the conservation biological control of leafroller pests [9]. Entomophilous flowering plants providing nectar showed a positive correlation to ladybird abundance and aphid parasitism [8]. Ample of natural enemies *viz.*, predatory bugs (*Nesidiocoris* spp), coccinellids, chrysopa, syrphid and spiders were noticed on all the crops raised under entomophage park. In general, predatory population was noticed in tobacco, maize, cotton, redgram, marigold and bengalgram [10]. These reports are in conformity to our results.

Population of natural enemies and insect pests on tobacco grown nearby entmophage biodiversity park and away from it (Table 2) revealed more or less similar trend throughout the crop season. The infestation of whitefly, leaf eating caterpillar, capsule borer, spiders and predatory bugs remain statistically at par in a tobacco raised near and away from entomophage biodiversity park (Table 3).

The study carried out by Armin *et al.*, (2016) [8] demonstrated that the local plant community affects the regulation of crop herbivores and suggested a negative relationship with major crop plant damage caused by leaf-chewing invertebrates. Further our results indicated that tobacco grown near and away showed more or less similar population of insect pest might be due to abiotic factors preventing population buildup of insect pest in tobacco crop.

Spider have no significant correlation with any abiotic factors. Coccinellids had highly significant negative correlation with BSS, WS, Min T, Mean T, RH_1, RH_2, Mean RH, VP_1, VP_2 and Mean VP. Among the predatory bugs, *Geocoris ochropeterus* showed significant negative correlation with WS, RH_2 and Mean RH_2, while *Nesidiocoris tenuis* established highly significant negative correlation with BSS, Min T, Mean T, RH_1, RH_2, Mean RH, VP_1, VP_2 and Mean VP (Table 4).

Shivanna *et al.*, (2016) [10] reported that minimum and maximum temperatures were negatively correlated with spiders on maize, redgram, and cotton. Afternoon relative humidity was positively correlated with predatory bugs on marigold, maize and redgram, crysopids and spiders on marigold as against its negative correlation with coccinellids on cotton. The slight deviation in our results may be due to location and crop raised under entomophage biodiversity park.

The weed, kuvadio (*Cassia* sp) raised under entomophage biodiversity park was observed and it was noticed that eggs of *Catopsilia* sp was found on the leaves during the flowering stage which is natural host of, *Trichogramma* sp an egg parasitoid of lepidoptera.

Yousuf *et al.*, (2015) [11] reported that the eggs of *Catopsilia pyranthe* is host of *Trichogramma* sp. Conservative biocontrol is more suitable for tobacco as it aims at modifying the crop ecosystem to conserve the native natural enemies and enhance their activity to keep the pest population under check [3].

4. Conclusion

The findings of an experiment on entomophage biodiversity park along with two separate plots of tobacco near and away revealed the activity of various natural enemies like spider, coccinellids, *Nesidiocoris tenuis*, *Geocoris ochropeterus* and *Rhynocoris* sp, were found on different crops raised under entomophage park. Out of various bio agents maximum activity of *N. tenuis* was found in tobacco. The population of coccinellids were build up in flowering crops like marigold, cotton, and maize. The population of spiders were present in all the crops raised under biodiversity perk. The abundence of natural enemies and insect pests on tobacco grown nearby entmophage biodiversity park and away from it revealed more or less similar trend throughout the crop season. Entomophage biodiversity park suggestively boosted the fecundity and survival of the natural enemies of the crop pest and such parks may play an imperative role in maintaining the biodiversity and augment natural enemies lead to natural pest control.

5. Acknowledgement

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Table 1: Population of natural enemies in entomophage park

SMW	Tobacco /m²					Lucerne / m²					Marigold / m²					Sena / m²					Cassia / m²					Maize / m²					Cotton / m²				
	Sp	LB	Ge	Ne	Rh	Sp	LB	Ge	Ne	Rh	Sp	LB	Ge	Ne	Rh	Sp	LB	Ge	Ne	Rh	Sp	LB	Ge	Ne	Rh	Sp	LB	Ge	Ne	Rh	Sp	LB	Ge	Ne	Rh
33	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	1	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
36	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
38	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
40	0	0	0	3	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	2	0	0
42	0	0	0	4	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2	0	0
43	0	0	0	5	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2	0	0
44	0	0	0	6	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	2	2	0	0
45	1	0	0	3	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	3	0	0
46	0	0	1	4	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	2	1	0	0
47	0	0	2	4	1	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	3	1	0	0
48	1	0	1	3	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	1	0	0
49	0	0	0	4	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	1	2	0	0	0
50	0	0	0	4	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	3	0	0	0
51	0	0	0	5	1	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0
52	0	0	2	6	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0
1	0	0	0	6	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	2	0	0	0
2	0	0	0	6	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0
3	0	0	0	6	1	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	2	0	0	0
4	0	0	0	5	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0
5	0	0	0	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
6	0	0	0	6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	1	0	0
7	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	1	0	0

SMW: Standard Meteorological Week, Sp: Spider, LB: Lady Bird Beetle, Ge: *Geocoris ochropeterus*, Ne: *Nesidiocoris tenuis*, Rh: *Rhynocoris* sp.

Table 2: Studies on insect pests of tobacco, its natural enemies near & away from entomophage park 2018-19

SMW	Tobacco /M² (Near)						Tobacco /M² (Away)					
	Natural enemies			Insect pests			Natural enemies			Insect pests		
	Spider	Predatory bug	Total	White fly	Leaf eating caterpillar	Capsule borer	Spider	Predatory bug	Total	White fly	Leaf eating caterpillar	Capsule borer
33	0	1	1	0	1	0	0	1	1	0	1	0
34	0	1	1	0	1	0	0	1	1	0	1	0
35	1	1	2	2	1	0	1	1	2	2	1	0
36	0	2	2	1	0	0	0	2	2	1	0	0
37	1	3	4	2	1	0	1	3	4	2	1	0
38	0	2	2	2	1	0	0	2	2	2	1	0
39	1	2	3	2	1	0	0	1	1	2	1	0
40	0	1	1	1	0	0	1	2	3	2	0	0
41	1	2	3	2	0	0	1	2	3	1	0	0
42	1	6	7	2	0	0	1	5	6	2	0	0
43	0	5	5	3	0	0	0	6	6	3	0	0
44	0	5	5	3	0	0	0	5	5	3	0	0
45	0	3	3	3	0	1	0	3	3	3	0	1
46	1	3	4	2	0	2	1	3	4	3	0	1
47	0	4	4	3	0	1	0	4	4	2	0	2
48	0	3	3	3	0	2	0	3	3	3	0	2
49	0	3	3	4	0	1	0	3	3	3	0	2
50	0	2	2	3	0	2	0	3	3	4	0	1
51	0	4	4	4	0	3	0	5	5	4	0	3
52	0	4	4	3	0	3	0	4	4	3	0	4
1	0	5	5	4	0	4	0	4	4	5	0	3
2	0	6	6	4	0	4	0	6	6	3	0	4
3	1	5	6	4	0	3	0	7	7	4	0	3
4	0	7	7	3	0	2	0	7	7	3	0	3
5	0	4	4	3	0	2	0	5	5	2	0	4
6	0	5	5	4	0	1	0	4	4	4	0	2
7	0	6	6	3	0	1	0	7	7	3	0	1
Total	7	95	102	70	6	32	6	98	104	69	6	36

Table 3: Summary on population of natural enemies and insect pest appear near and away from entomophage biodiversity park

Entomophage Biodiversity park	Population of natural enemies/m^2		Population of insect pest/m^2		
	Spider	Predatory bug	Whitefly	Leaf eating caterpillar	Capsule borer
Near	0.222	3.519	2.593	0.222	1.185
Away	0.259	3.407	2.556	0.222	1.333
't' value	-0.313	0.222	0.116	0.000	-0.389

Table 't' value @ 0.05% = 2.007, Table 't' value @ 0.01% = 2.674

Table 4: Correlation of abiotic factors with natural enemies in entomophage biodiversity park

Weather parameter	Spider	Coccinellids	*Geocoris chloropterus*	*Nesidiocoris tenuis*	*Rhynocoris* sp.
EP	-0.051	-0.294	0.275	-0.049	-0.167
BSS	0.164	0.608**	0.452*	0.664**	0.311
WS	-0.332	-0.545**	-0.538**	-0.416*	-0.437*
Max T	0.358	-0.259	0.339	-0.429*	0.239
Min T	0.087	-0.773**	-0.179	-0.835**	-0.162
Mean T	0.216	-0.623**	0.033	-0.739**	-0.001
RH_1	0.053	-0.550**	-0.410*	-0.605**	-0.077
RH_2	-0.102	-0.713**	-0.564**	-0.753**	-0.288
Mean RH	-0.065	-0.717**	-0.559**	-0.764**	-0.249
VP_1	0.052	-0.758**	-0.215	-0.838**	-0.216
VP_2	0.038	-0.771**	-0.343	-0.875**	-0.181
Mean VP	0.046	-0.772**	-0.280	-0.865**	-0.201

*Significant ** highly significant,

EP = Evaporation, BSS= Bright Sunshine hours, WS= Wind speed, Max T=Maximum temperature, Min T=Minimum temperature, Mean T=Mean temperature, RH_1 & RH_2= Relative humidity (morning and afternoon), Mean RH= Mean relative humidity, VP_1& VP_2= Vapor pressure (morning and afternoon), Mean VP= Mean vapor pressure

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