Indian Journal of Entomology, 81 Online published, IJE 19019/August 2019

Indian Journal of Entomology, **81**(3): 000-000 (2019) DoI No.:

POPULATION DYNAMICS OF SOIL MESOFAUNA IN SOYBEAN

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ABSTRACT

This study is on the interaction between soil biological characteristics and weather factor with an field experiment conducted at the UAS, GKVK, Bengaluru. Significant difference in abundance of soil fauna was documented among the treatments, of which the best treatment (20 t farm yard manure/ ha) for mesofauna was correlated with weather factors. The results revealed their significance. Maximum and minimum temperature were observed significantly negatively correlated, while soil moisture and relative humidity were positively linked. The contribution of such abiotic factors to the abundance of soil mesofauna (67%), Collembola (70%), Cryptostimata (67%), other acari (65%), total acari (70%), other invertebrates (39%) was brought out.

Keywords: Soybean, soil mesofauna, Collembola, Cryptostigmata, Acari, farm yard manure, soil moisture, temperature, humidity

In soybean (*Glycine max* (L) Merril) organic amendments adds large amounts of organic matter, and this provides support for soil mesofauna. This useful mesofauna includes protozoans, nematodes, oligochaete worms (earthworms and enchytraeids), mites, collembolans, millipedes, centipedes and a range of insects whose larval stages complete their development in the soil (Wallwork, 1976). However, sustainability of these depends largely on the abiotic factors. Mesofauna like Collembola commonly consume fungal hyphae and spores, but also have been found to consume plant material, pollen, animal remains, colloidal materials, minerals and bacteria. Most frequently they found in leaf litter and other decaying material located 15 cm below the ground surface (Chen et al., 1996). Addition of organic matter in the form of manures holds sufficient moisture and encourages mainly the diversity and abundance of litter dwelling animals. Cryptostigmatids are an ancient group of arachnids with an evolutionary history extending back at least to the lower Jurassic period (Wallwork, 1976). Salmane (2000) reported that the presences of mites in a favourite ecosystem depend on the abiotic factors like: relative humidity, temperature of air, moisture and pH of soil. Any disturbance of these factors generates modifications of numerical densities. The present study brings out the relationship among soil mesofauna and weather factors including soil moisture.

MATERIALS AND METHODS

The studies on the relationship between soil fauna with abiotic factors was carried out in organic farming soybean (MAUS-2) ecosystem at Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru. The soil belongs to Vijayapur series and is classified as oxic Haplustalf. According to FAO classification, the soil is Ferric Luvisols. The experiment was a long-term one initiated in 2001 to know the effect of organic and inorganic fertilizers on the abundance and diversity of soil arthropods in the cropping system. The initial soil chemical properties are organic carbon (0.34%), available phosphorus (11.69 kg/ha), available potassium (120.50 kg/ha), exchangeable calcium (6.6 meq/100g.), exchangeable magnesium (3.62 meq/100g.) and pH (5.92) were recorded during the year 2001. Study was a randomized complete block design with following treatments and three replications were maintained as follows viz., T1. Recommended fertilizers (25:60:25 NPK Kg per ha) + Recommended FYM (10 tonnes per ha) + phorate 10 G @ 1 kg a.i./ ha + herbicide (Lasso 50 EC @ 2.5 l/ ha) + fungicide seed treatment (Thiram + Bavistin- each 2g/ kg of seeds). (University package practice for soybean); T2. 12.5 t of FYM/ ha + 75% of recommended fertilizer; T3. 15.0 t of FYM/ha + 50% of recommended fertilizer; T4. 17.5 t of FYM/ ha + 25% of recommended fertilizer; T5. 20.0 t of FYM/ ha; T6. 10.0 t of FYM/ ha; T7. 10.0 t of

FYM/ ha (partially decomposed); T8. 10.0 t of FYM/ ha + mulching (Glyricidia 2 t/ ha.); T9. Recommended fertilizer alone; T10. 5 t of FYM/ ha (Note: N- Nitrogen, P- Phosphorous, K- Potassium, T- Treatment, FYM- Farm yard manure).

The mesofauna were extracted from the soil samples using Rothamsted modified Mac Fadyen high gradient funnel apparatus. The apparatus was allowed to run for 48 hr. The invertebrates present in the soil passing through 2 x 2 mm sieve of the sample holder were collected in vials containing 70% ethyl alcohol fixed to the lower end of the funnel. A stereozoom microscope (35x magnification) was used for sorting and identification of extracted soil invertebrates. Whereas macrofauna was collected by pitfall method from each treatment under three replications. Samples were collected at fortnightly intervals, and simultaneously weather parameters data, in situ soil temperature and soil moisture were recorded. Soil temperature was recorded by inserting soil thermometer into the soil to a depth of 10 cm at the time of each sampling period in each treatment and readings were noted down. In situ soil moisture was estimated on weight basis. Other abiotic factors viz., atmospheric temperature (maximum and minimum), relative humidity (maximum and minimum), sunshine hours and rainfall at the experimental location were obtained from the meteorological station at UAS, GKVK, Bengaluru.

Data were transformed using $\sqrt{x+0.5}$ transformations, wherever necessary and statistically analyzed for ANOVA (Sundararaj et al., 1972). The correlation coefficients were worked out with multiple correlation analysis to find out the relationship between the abundance of mesofauna and weather parameters including soil temperature and moisture.

RESULTS AND DISCUSSION

During cropping season soil samples harboured significantly higher abundance of mesofauna and macrofauna. Significant mesofaunal differences were noticed in 30 and 45DAS (days after sowing), with maximum abundance being in treatment with 20 t of FYM, while the least was with fertilizers (Table 1). It might be due to better availability of food (organic matter and microbial biomass), optimum soil moisture and temperature (Morris, 1922; Ayuke et al., 2004). The abundance of soil fauna increased gradually from BAT (before application of treatments) to crop growth period, but decreased after 105 DAS. During non cropping season, lower abundance of soil mesofauna was observed, with maximum abundance being at 105 DAS which reduced gradually up to 240 DAS (Table 2); this can be attributed to low soil moisture content and increase in the soil temperature without rainfall, exposure to sunlight with no cover crop and non-availability of suitable food; maximum abundance was at 120 DAS, and this might be due to the rainfall in the previous fortnights, which increased the soil and food moisture. Similar observations had been reported by Hazra and Choudhari (1978) and Mahajan and Singh (1981).

Table 1. Organic manure and fertilizers vs. abundance of soil fauna in soybean (cropping season)

Treatment	Mesofauna												
	75 BAT	60 BAT	45 BAT	30 BAT	15 BAT	10 DAS	20 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
T_1	4.3^{a}	4.6^{a}	6.0^{a}	5.3^{ab}	4.0^{dc}	6.3^{ba}	6.3^{bdec}	13.6^{b}	13.0^{bc}	16.0^{ba}	20.6^{bac}	25.0^{b}	35.3^{b}
T_2	3.6^{a}	6.0^{a}	6.3^{a}	6.3^{a}	7.6^{ba}	7.66^{a}	8.6^{ba}	8.0^{cb}	9.6^{cd}	13.3^{ba}	22.3^{bac}	67.6^{a}	40.0^{ba}
T_3	4.3^{a}	5.6^{a}	6.3^{a}	6.6^{a}	3.0^{d}	5.0^{ba}	6.6^{bdac}	8.3^{cb}	16.0^{ba}	18.0^{ba}	25.0^{ba}	22.3^{b}	39.6^{ba}
T_4	3.6^{a}	5.0^{a}	7.6^{a}	3.6^{ab}	3.6^{dc}	6.3^{ba}	5.6^{dec}	10.6^{cb}	19.3^{a}	18.3^{ba}	17.6^{bc}	33.3^{b}	43.6^{ba}
T_5	5.3^{a}	6.6^{a}	8.0^{a}	7.6^{a}	9.3^{a}	7.3^{a}	9.3^{a}	23.3^{a}	15.6^{ba}	21.6^{a}	29.0^{a}	51.6^{a}	47.0^{ba}
T_6	3.0^{a}	3.0^{a}	4.3^{a}	3.6^{ab}	4.6^{bdc}	3.6^{b}	5.0^{de}	9.33^{cb}	15.6^{ba}	8.0b	15.3^{c}	40.0^{ba}	51.3^{a}
T_7	3.6^{a}	3.0^{a}	4.3^{a}	4.0^{ab}	5.3^{bdc}	5.0^{ba}	4.6^{de}	12.3^{b}	15.6^{ba}	14.6^{ba}	14.0	27.0^{b}	34.6^{b}
T_8	4.6^{a}	4.3^{a}	6.3^{a}	6.0^{a}	6.6^{bac}	4.6^{ba}	8.3^{bac}	8.6^{cb}	11.6^{bcd}	15.6^{ba}	21.6^{bac}	44.3^{ba}	43.3^{ba}
T_9	3.3^{a}	3.6^{a}	3.3^{a}	1.6^{b}	4.6^{bdc}	5.3^{ba}	3.6^{e}	4.3^{c}	7.66^{d}	10.3^{b}	18.6^{bc}	29.6^{b}	37.6^{b}
T_{10}	3.3	3.3^{a}	5.3^{a}	4.3^{ab}	6.6^{bac}	5.6^{ba}	7.0^{dac}	6.6^{cb}	10.0^{cd}	11.3^{ba}	14.6^{c}	27.0^{b}	39.6^{ba}
LSD	2.7163	4.1693	4.9376	4.2187	3.475	3.6013	2.9119	7.58	5.1747	11.215	9.2383	33.881	12.494
P value	0.8552	0.7021	0.7246	0.2550	0.0460	0.6024	0.0184	0.0084	0.002	0.44	0.08	0.26	0.32

Table 2. Organic manure and fertilizers vs. abundance of soil fauna in soybean (non-cropping season

Treatment	Mesofauna								
	120 DAS	135 DAS	150 DAS	165 DAS	180 DAS	195 DAS	210 DAS	225 DAS	240 DAS
T_1	31.6^{bc}	13.0^{bc}	19.3^{a}	11.3^{b}	11.0^{bac}	13.0^{ba}	4.0^{c}	5.6^{b}	2.3^{bc}
T_2	36.3^{bac}	19.3^{bac}	18.0^{a}	10.0^{b}	7.0^{c}	10.6^{ba}	4.6^{bc}	5.0^{ba}	1.6^{bc}
T_3	42.3^{a}	15.6^{bac}	21.0^{a}	15.6^{ba}	15.6^{a}	7.6^{ba}	5.0^{bc}	5.0^{ba}	4.3^{ba}
T_4	35.3^{bac}	26.3^{a}	12.3^{bac}	12.3^{b}	14.0^{ba}	8.6^{ba}	7.0^{a}	5.3^{ba}	5.66^{a}
T_5	40.6^{ba}	23.3^{bac}	20.0^{a}	20.3^{a}	15.3^{ba}	13.0^{ba}	7.66^{a}	5.6^{ba}	4.3^{a}
T_6	28.0^{dc}	20.0^{bac}	17.0^{ba}	13.6^{ba}	9.6^{bac}	20.0^{a}	4.6^{c}	6.3^{b}	4.0^{bac}
T_7	36.6^{bac}	13.0^{bc}	14.3^{bac}	9.3^{b}	9.3^{bc}	6.3^{ba}	5.0^{bc}	5.0^{ba}	2.3^{bc}
T_8	34.6^{bac}	24.3^{ba}	12.3^{bac}	10.6^{b}	13.6^{ba}	6.6^{ba}	4.0^{c}	8.0^{b}	4.3^{ba}
T_9	20.6^{d}	12.0^{c}	6.3^{c}	9.0^{b}	5.6^{c}	6.0^{b}	3.6^{c}	3.66^{ba}	1.3^{c}
T_{10}	27.6^{dc}	14.3^{bc}	8.0b^{c}	9.0^{b}	7.0^{c}	6.0^{b}	6.0^{ba}	3.6^{b}	2.6^{bc}
LSD	9.172	11.534	9.8597	6.7825	6.07	13.811	1.7058	4.0781	2.9876
p	0.0055	0.1091	0.1043	0.085	0.01	0.5316	0.0026	0.4292	0.1614

Mesofauna vs. abiotic factors

Significant relationships exist between the abundance of soil mesofauna and abiotic factors. Soil moisture at in situ showed significant positive correlation, while minimum and maximum temperature had a negative correlation with soil mesofauna (Table 3). Generally, community of soil arthropods was affected negatively rather than positively by high soil temperature, which is connected with the effect of evaporation and decrease in the soil moisture. But, this was disagreed with by Bhattacharya and Bhattacharya (1987), who reported that micro-arthropods in industrial area is negatively correlated with soil moisture.

The results obtained with maximum and minimum relative humidity, sunshine hours and total rainfall revealed a positive correlation (Table 3). Soil moisture and rainfall were the major factors influence the temporal variation pattern in the abundance of most of the micro-arthropod groups. These results agree with those of Bhattacharya and Bhattacharya (1987), that population density of soil Acarina of Himalayan ecosystem reached the maximum level in March, the spring season. Similar investigations by Choudhari et al. (1978), reported the positive correlation of soil fauna (Collembola) with soil moisture in grave yard.

The present study brings out the contribution of abiotic factors on the abundance of soil mesofauna (67%), Collembola (70%), Cryptostigmata (67%), Other acari (65%), total Acari (70%), and other invertebrates (39%) (Table 3). Collembolan and other invertebrates showed negative relationship with soil temperature, and irrespective of treatments the abundance of soil arthropods had a positive relationship with the soil moisture and a negative relationship to soil temperature. These results corroborate with earlier findings, that population density of soil fauna was negatively correlated with temperature in both habitats (forest and field), whereas soil moisture was positively correlated in cereal fields and negative in forest (Vatsa and Narula, 1990a). It was also observed that precipitation and temperature were significantly correlated with Collembola and Mesostigmata densities and also with total arthropods. The seasonal variation in the amount of litter fall was also significantly related to the abundance of arthropod in the litter layer biotope (Palacios et al., 2007).

The cryptostigmatids' abundance had a significant negative relationship with minimum temperature, and positive one with minimum and maximum relative humidity, sunshine hours, soil moisture and soil temperature (Table 3). Earlier studies revealed a positive correlation of soil fauna with soil moisture in deciduous forests (Sheela and Haq, 1991) and in banana (Joy and Bhattacharya, 1981).

Other Acari were observed to have a significant negative relationship with minimum temperature. These observations agree with those of Banerjee and Roy (1988) who reported that Acari in forest had

Table 3. Correlation and regression- soil mesofauna vs. abiotic factors in soybean

Particulars	Maximum temperature	Minimum temperature	Maximum RH	Minimum RH	Sunshine hours	Total rainfall	Soil moisture	Soil temperature	Regression equation	R^2 value
Soil mesofauna	-0.401	-0.543**	0.345	0.302	0.190	0.169	0.515*	0.017	$Y=77.373 + 0.571X_1 – 4.706X_2 –0.505X_3 – 0.639X_4 –0.171X_5 + 0.256X_6 + 0.914X_7 + 0.464X_8$	0.672
Collembola	-0.379	-0.035	0.370	0.570**	0.469*	0.612**	0.636**	-0.165	$Y= 43.129 + 0.001X_1 - 0.986X_2 - 0.414X_3 + 0.317X_4 - 0.111X_5 + 0.312X_6 + 0.408X_7 - 0.082X_8$	0.700
Other acari	-0.362	-0.644**	0.300	0.182	0.056	-0.047	0.399	0.108	$Y= 9.357 + 0.490X_1 – 1.910X_2 + 0.013X_3 + 0.212X_4 + 0.038X_5 - 0.102X_6 +0.225X_7 + 0.130X_8$	0.656
Cryptostigmata	-0.301	-0.702**	0.279	0.084	0.019	-0.117	0.313	0.048	$Y=14.599 + 0.220X_1 – 1.489X_2 – 0.096X_3 +0.224X_4 + 0.009X_5 - 0.060X_6 + 0.237X_7 + 0.228X_8$	0.674
Total acari	-0.308	-0.722**	0.235	0.049	-0.047	-0.165	0.305	0.141	$Y= 31.778 + 0.530X_1 – 3.613 X_2 – 0.087X_3 + 0.034X_4 - 0.073X_5 – 0.045X_6 + 0.509X_7 + 0.589X_8$	0.702
Other invertebrates	-0.216	-0.201	0.388	0.307	0.070	0.046	0.092	-0.381	$Y= - 3.220 + 0.121X_1 –0.099X_2 + 0.027X_3 + 0.051X_4 + 0.028X_5 - 0.036X_6 - 0.018X_7 – 0.073X_8$	0.392

*Significant at p= 0.05%; **p= 0.01; Figures given coefficient of correlation (r); RH: relative humidity, X_1= Maximum temperature, X_2= Minimum temperature, X_3= Maximum relative humidity, X_4= Minimum relative humidity, X_5= Sunshine hours, X_6= Total rainfall, X_7= Soil moisture, X_8= Soil temperature.

positive correlation with soil moisture. The maximum temperature and total rainfall showed negative non-significant correlation. The contribution of these abiotic factors on other Acari abundance was 65% (Table 3). Similarly, Narula et al. (1996), reported that soil temperature and moisture are of importance in determining the abundance and diversity of soil fauna.

From the present study, it can be inferred that abiotic factors play an important role on soil and litter dwelling mesofauna. In general, soil mesofauna was predominant in the rainy season with peak population during vegetative growth stage. Addition of organic manure in the form of FYM elevates moisture holding capacity of soil and supports maximum meso faunal abundance.

ACKNOWLEDGEMENTS

The authors thank the Department of Entomology, UAS, GKVK, Bengaluru for facilities and Indian Council of Agricultural Research for the financial support.

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(Manuscript Received: February, 2019; Revised: August, 2019; Accepted: August, 2019; Online Published: August, 2019)