"Studies on Linear Regression of Nematode Population in Relation with Soil Abiotic Factors Associated with Mulberry, *Morus alba* L. from Sillod, Aurangabad (M.S), India."

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Abstract: Mulberry is an important plant in the economy because silk production depends on the nutritive quality of the leaves. Mulberry, *Morus alba* L. was selected to studies on linear regression of nematode population in relation with soil abiotic factors. The soil samples were collected from the Mulberry garden from Sillod, Aurangabad. The population was investigated at 10-15 cm depths. The result shows that, there is variation in nematode count and it is due to the effect of temperature, soil moisture and pH during the study.

Keywords: *Morus alba* L., Soil moisture, Temperature, pH, linear regression, Nematode population.

Introduction:

Mulberry (*Morus alba* L.), the sole food plant of silkworm (*Bombyx mori* L.), is cultivated both in tropical and temperate countries of the world. India is the second largest country in the world having 3.42 lakh hectares under mulberry cultivation (Govindaiah and Sharma, 1994). The major constraint in the cultivation of mulberry and production of quality mulberry leaves is the attack of the pests and diseases including plant parasitic nematodes. The plant parasitic nematodes have wide range of host plants and cause economic damage to many agricultural crops. Several plants in parasitic nematodes species belonging to different genera have been encountered in the rhizosphere soil of mulberry gardens. Mulberry being a perennial crop, the nematode readily perpetuate and spread entire root system to cause rottening and decaying of roots. The root knot nematode, Dagger nematode and Spiral nematode which cause significant losses in mulberry production (Ramkrishnan et al., 2003).

The main climatic factors to exert an influence on the development of nematodes are temperature and humidity. Furthermore, these conditions are themselves interrelated and hence any ecological action is perforce heterogeneous. The other three soil factors which have been selected in the present scheme of work are soil temperature, moisture and pH. Temperature and moisture have direct bearing in controlling the activity and metabolism of animal community as well as that of nematodes also. pH has little direct impact upon the higher and lower animals but for soil borne microorganisms, hardly we can neglect their impacts. So altogether these three soil parameters, namely soil temperature, moisture and pH were considered to assess their impact upon the soil nematodes. Soil temperature is one of the major environmental factors, affecting the physiology of plant parasitic nematodes, infesting various crops of national importance. Different nematode activities like hatching, reproduction, movement, development, etc. require different temperature range. Temperature range may vary with the type/species of host plant, and nematodes of different age, stage and degrees of starvation may behave differently. Further, various populations within the same species may need different temperature requirements. There are several phases of the effect of temperature requirements. (Sohlenius 1968, 1973, 1985; Anderson and Coleman 1982 and Rossner and Nagel 1984).

The statistical analysis of population of plant and soil nematodes started in the last decades of this century. The interspecific correlation and regression analysis of population densities of *Tylenchorhynchus spp. Rotylenchus reniformis* and *Hoplolaimus indicus* were studied by Gaur and Haque (1986). Saeed and Ashrafi (1971) studied the fluctuation of nematode population in banana and tried to correlate them with environmental factors. The population density of nematode varies considerable due to several factors like availability of host plant, soil type, soil moisture, soil temperature, rainfall and many other extrinsic factors (Norton, 1979).

It would be worthwhile to quote Price and Siddiqi (1994) to establish the justification of the present study "This suggest a role for the study of plant and soil nematodes in investigating, quantifying and monitoring past, present and future environmental changes. Such work could be restricted to the genus of Tylenchida (due to their diversity and potential economic importance) and of the Dorylaimida (due to their potential ecological significance) ....." The present investigation study shows that, there is variation in nematode count and it is due to the effect of Soil temperature, Soil moisture and Soil pH during the study.

Material and methods:

Soil sample collection and nematode extraction for count: The soil samples were collected from the Mulberry garden from Kaigaon, Sillod tehsil of Aurangabad Districts. In various soil variables such as Temperature, pH and Soil moisture are noted at time of soil sampling take place. The soil samples for this study were collected from mulberry farm of various farmers during 2009-2011. Two hundred cubic centimeter of soil were sampled at depth 0-15 cm. Soil samples from various farm were pooled, thoroughly mixed before taken 200 cm^3 of the representative sample for nematode extraction using Cobbs sieving and decanting method with Baermann techniques. The sample method is very simple i.e. pooled two samples from random sampling method from collection site of mulberry garden and further procedure as above. Then note down their mean value as nematode count.

Preservation and mounting of nematode: Batches of the extracted nematodes were inactivated in water bath at 60-70 ºC, fixed in FA 4:1 fixative cleared in a glycerol-ethanol solution by slow evaporation of the ethanol and stored in anhydrous glycerol. Microscopic examination and photographing of the nematodes was done in glycerol mounts.

Estimation of soil abiotic factors of mulberry field: A portion of soil samples, collected from mulberry selected for ecological studies was kept separate to estimate the soil abiotic factors like soil moisture, pH and temperature. The methods of estimation as follows:

Preparation of soil for testing: The soil samples were thoroughly air dried under shade, grinded into fine particles, and was passed through 2mm pore size sieve. The soils were stored in containers with label of locality and month of collection for subsequent analysis.

Estimation of Soil Temperature: Soil temperature was recorded every month from Mar.2009- Apr. 2011 from mulberry field at the time of collecting soil samples between 11 AM to 12 PM with the help of soil thermometer. The thermometer was pushed into soil at least up to 10 cm depth keeping there until a constant temperature was reached and the temperature was reached and the temperature was recorded.

Estimation of Soil pH: With the help of soil pH meter the pH of soil is note on the field during the soil samples collection time.

Estimation Soil moisture: Weighing 10 gm of soil then take it in the oven at temperature around 105°C overnight and re-weight.

$$\text{Soil moisture (\%)} = \frac{\text{Wet soil weight (gm) - Dry soil weight (gm)}}{\text{Dry soil weight (gm)}} \times 100$$

Statistical analysis with the estimated data: Finally, the data obtained from monthly population count of the genera belonging to the orders Tylenchida, Dorylaimida and Mononchida along with the estimated soil abiotic factors from the respective mulberry field were subjected to appropriate statistical analysis, e.g., correlation and linear regression analysis, to realize the relation between them by using Minitab 16 software.

Results and Discussion:

1. Population fluctuation of the nematode orders Dorylaimida, Tylenchida, Mononchida and nematodes of other orders in mulberry garden of Sillod tehsils.

In **Sillod** tehsil mulberry garden, the maximum total population abundance, i.e., the totality of all (Juveniles and adults) Dorylaimids, Tylenchids, Mononchids and other nematodes, was observed in month of August among all twenty-four months of observations, the mean of total population being 306 / 250 gm of soil in August 2009, 431 in August 2010. The minimum total population was recorded in the month of May 2010-11, the mean population being 54 and 28 (Table. 1 and Fig. 1).

The maximum population of Tylenchida was noticed in August 2009 (115 / 250 gm of soil respectively) and August 2010 (149). Tylenchids were counted minimum in March, April and May 2010-11, being 45 and 24, 21 and 11, 16 and 8 respectively. Like-wise, the mean population abundance of Dorylaimida was observed to be the highest in the month of August in two consecutive years (124 in 2009 and 163 in 2010). The mean population of Dorylaimida was counted lowest in April and May 2010-11, being 29 and 15, 22 and 14 respectively. The distinct population peak of Mononchida was well pronounced in August 2009-10 (43 and 72 respectively). It remained distinctly minimum in February, March, April and May 2010-11, being 8 and 12, 14 and 9, 11 and 7, 10 and 4 respectively. The highest population of nematodes belonging to other orders, i.e. of 'other nematodes' was encountered in August 2009 is 24 and August 2010 is 47. The least population was recorded in February, March, April and May 2010-11, being 7 and 10, 11 and 8, 8 and 5, 6 and 2 respectively. The data regarding the monthly population fluctuation of Tylenchida, Dorylaimida, Mononchida and other nematodes in Sillod mulberry garden is shown in Table.1 and in Figure. 1.

In the present observation, the total population of all the nematode orders started up coming from the month of June for the years under study and maintained high population abundance up to the month of January, reaching its highest in the month of September. In the year 2009 as well as 2010 – 11, the population started declining notably in February to May followed by June- July. The seasonal variations in the population of plant and soil nematodes discussed by many scientists like Oostenbrink (1960), Seinhorst, (1967, 68), Feris and Bernard (1967), Wallace (1969), Brodie *et al*. (1970a, 1970b, 1970c), Khan *et al*. (1971), Szczygiel and Hasior (1972), Chaturvedi and Khera (1979) and Ahmad and Jairajpuri (1982). Population dynamics of plant parasitic nematodes associated with mulberry in Egypt by Youssef (1998) revealed that Seasonal fluctuation of plant parasitic nematodes associated with mulberry showed a peak of *Rotylenchulus reniformis* in March and August and population of *Paratylenchus* sp., showed a peak in January, May and July.

Gantait *et al*., (2006) shows very much close findings of Monthly population fluctuation of four plant parasitic nematodes, *Rotylenchulus reniformis, orhynchus coffeae, Helicotylenchus crenacauda* and *Hoplolaimus indicus* associated with banana plantation (*Musa paradisiaca cv* 'Kanthali'), *Tylench* was studied in Paschim Medinipur District, West Bengal, India, during March 2004 to February 2005. All the four species reached at peak in August, then declined till January. In March, a second but smaller peak was seen, followed by a decline till June. Thus, a bimodal population fluctuation has been observed in all the cases.

Sharma and Sarkar (1998) were undertaken a survey in 11 major localities of Mysore district (Karnataka, India) to determine the incidence, intensity and prevalence of Meloidogyne species/ races under different farming systems and soil types of mulberry gardens. The disease incidence not at all noticed under rainfed condition. Based on parasitism on different host plants, the species has been identified as *Meloidogyne incognita* as reported earlier by Narayanan *et al.*, (1966) and Govindaiah *et al.*, (1989) on mulberry. The present findings are in conformity with that of Govindaiah *et al.*, (1994) who reported race-2 of M. incognita affects mulberry. The race-2 of *M. incognita* also reported by Khan and Haider (1991), Khan and Khan, (1990), Khan *et al.*, (1993) and Prasad and Nath, (1996).

The population of the 'other nematodes' fluctuated throughout the year shows maximum in month of august and September during 2009-10.There was no remarkable variation in occurrence of the "other nematodes" population in present study. They maintain high build up in their population from august to December in two years observation. Drastic decline was observed in March, April and May 2010-11. The similar results were observed by Ghosh and Manna (2008) in paddy crops for two years.

2. Correlation and Regression analyses of the nematode orders Dorylaimida and Tylenchida in mulberry garden of Sillod tehsils.

In **Sillod** mulberry garden, the population of different genera of Dorylaimida and Tylenchida have negative impact of temperature on their population growth (correlation coefficient (r) lies between (-) 0.359 to (-) 0.614 for different genera, $P \leq 0.05$). The *Meloidogyne* genus having r = (-) 359 which does not show significance. On the contrary, pH of soil also affected the population of all the genera having negative impact on their population growth (correlation coefficient (r) lies between (-) 0.652 to (-) 0.845 for different genera, $P \leq 0.05$). The population growths of Dorylaimids were positively correlated with the moisture content of the soil at a significant level (correlation coefficient (r) lies between (+) 0.713 to (+) 0.881 for different genera, $P \leq 0.05$) whereas, the Tylenchids population showed significant relationship (r ranges between (+) 0.739 to (+) 0.780, $P \leq 0.05$).

The data regarding the mean population of Tylenchids and Dorylaimid genera and the estimated monthly mean value of soil abiotic factors in Sillod tehsil mulberry garden are shown in Table No. 1 and in Figure No. 2, 3, 4 and 5 respectively.

The populations of different genera of Dorylaimida and Tylenchida have negative impact of temperature on their population growth ($P \leq 0.05$). The *Meloidogyne, Pratylenchus* and *Xiphinema* genus having ($P \leq 0.05$) which does not show significance. But other genera i.e. *Helicotylenchus*, *Eudorylaimus*, *Mesodorylaimus* and *Discolaimus* having ($P<0.02$) which shows significant correlation coefficient (r) values. The results shows similar with Youssef (1998) revealed that Seasonal fluctuation of plant parasitic nematodes associated with mulberry showed a peak of *Rotylenchulus reniformis* in March and August which was negatively correlated (r = 0.03) with the prevalent soil temperature. Population of *Paratylenchus* sp., showed a peak in January, May and July which was negatively correlated (r = 0.01) with the soil temperature. Gantait *et al.,* (2006) has made an attempt to correlate the population change of the species with soil factors like temperature, moisture, pH, and organic carbon content. Temperature, moisture and organic carbon showed positive correlation with the population whereas pH showed negative correlation. This study shows opposite results of our findings.

Annamalai *et al*., (1996) also similar findings for the population of *Pratylenchus jordanensis* in soil did not vary significantly and was high throughout the year. However, the population was lowest in May and August at the first and second site, respectively. The correlation between nematode soil populations and soil temperature was not significant ($P > 0.05$). In contrast with me soil population, nematode populations in roots fluctuated greatly with a distinct high from July to November at both locations, which coincided with higher soil temperatures. In spite of the presence of a high nematode population in the soil, the population in roots was very low from December to June, coinciding with lower soil temperatures. These findings were confirmed by the positive correlations between the populations in roots and the soil temperature (r = 0.433 and 0.324; $P = 0.01$), represented by the linear regression equations, $Y=78.45+29.43x$ and $Y=76.11+3.38x$. The high nematode population in roots from July to November suggested that the penetration and/or reproduction of *P jordanensis* into roots were favored by high soil temperature.

Soil moisture is one of the major factors in regulating the nematode population being related mainly to rainfall of a particular area. In the present study, significant population growth of Dorylaimids occurred with the increasing moisture content of the soil (P<0.05). Khan and Sharma (1990) observed no considerable role of moisture on some nematode species having negative correlation with population build-up in apple orchard which contradicts the present observation in its extreme. On the other hand a positive correlation was observed between certain genera and rainfall in pastures (McSorley, 1997), which helped to maintain a consistent increase in plant feeders with increasing soil water in prairie system (Todd *et al.*, 1999) and that of omnivores and predators in an irrigated orchard (Porazinska *et al.,* 1998). Griffin *et al*. (1996) concluded that the positive relationship exists between high soil water and maximum population densities of *Tylenchorhynchus acutoides.* But in the present investigation although the population of tylenchids was highest during monsoon, still they showed no significant correlation with soil moisture (P>0.10).

In practical and honest confession, we must have to agree with, that the growth / decline of the overall nematode population, in a naturally occurring ecosystem, are the resultant of the simultaneous interaction of all the available biotic factors of the soil and nematode population. On this background, a trial to determine the effectiveness of a biotic factor, on the population would not be practically feasible.

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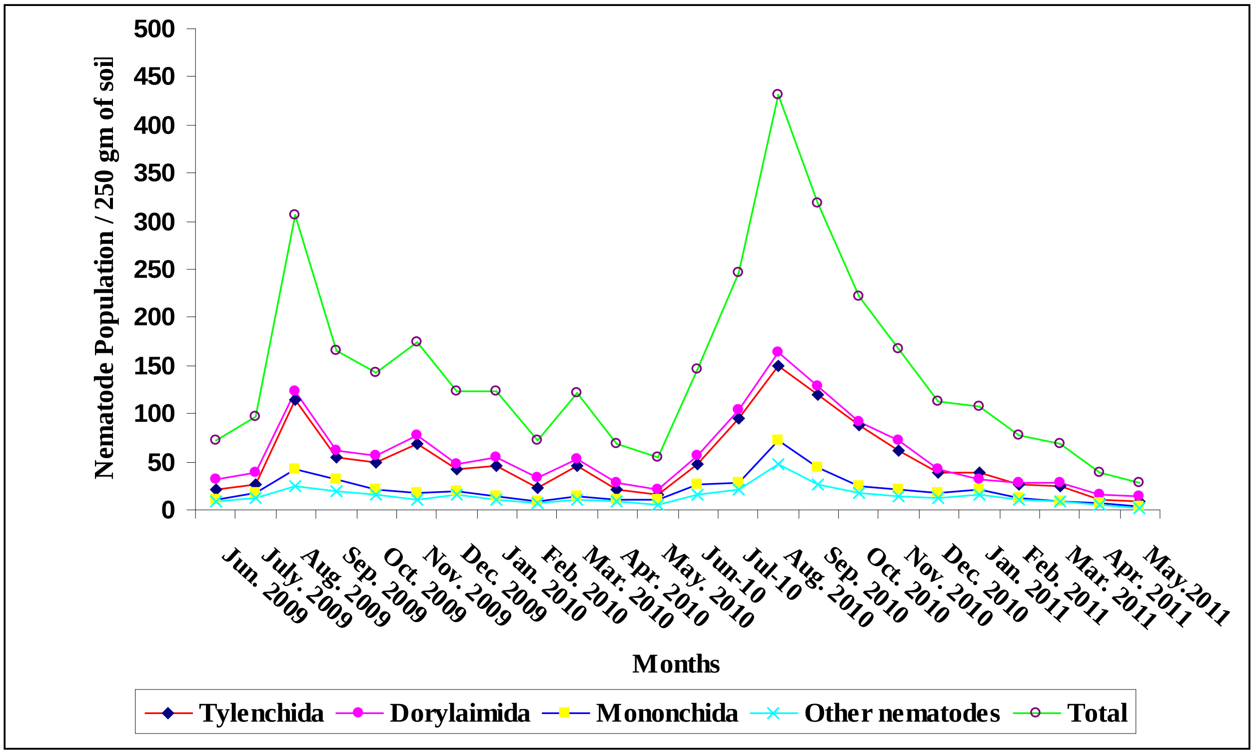
Genera	**Temperature (^{0}C)**	**Moisture (%)**	**pH**
Meloidogyne	- 0.359 ^{NS}	0.780*	- 0.804*
Helicotylenchus	- 0.576*	0.777*	- 0.749*
Pratylenchus	- 0.567*	0.739*	- 0.709*
Eudorylaimus	- 0.575*	0.881*	- 0.816*
Mesodorylaimus	- 0.544*	0.831*	- 0.845*
Aporcelaimellus	- 0.463*	0.674*	- 0.652*
Discolaimus	- 0.614*	0.839*	- 0.801*
Xiphinema	- 0.452*	0.713*	- 0.679*

Table: 1. Correlation coefficients (r) between nematode genera and different soil abiotic factors in Sillod Mulberry garden (* Significant correlation, P ≤ 0.05).

Figure: 1. Month wise man population (adults and juveniles) of Tylenchida, Dorylaimida, Mononchida and other nematodes / 250 gm of soil in mulberry garden in Sillod tehsil.


Nematode Population / 250 gm of soil
500
450
400
350
300
250
200
150
100
50
0
Jun. 2009
July. 2009
Aug. 2009
Sep. 2009
Oct. 2009
Nov. 2009
Dec. 2009
Jan. 2010
Feb. 2010
Mar. 2010
Apr. 2010
May. 2010
Jun-10
Jul-10
Aug. 2010
Sep. 2010
Oct. 2010
Nov. 2010
Dec. 2010
Jan. 2011
Feb. 2011
Mar. 2011
Apr. 2011
May.2011
Months
Tylenchida
Dorylaimida
Mononchida
Other nematodes
Total

ISSN 2229-5518

Figure: 2. Linear regression of Tylenchid population (genus *Meloidogyne* and *Helicotylenchus*) in relation with soil abiotic factors (as mentioned on X- axis) in Sillod mulberry field.

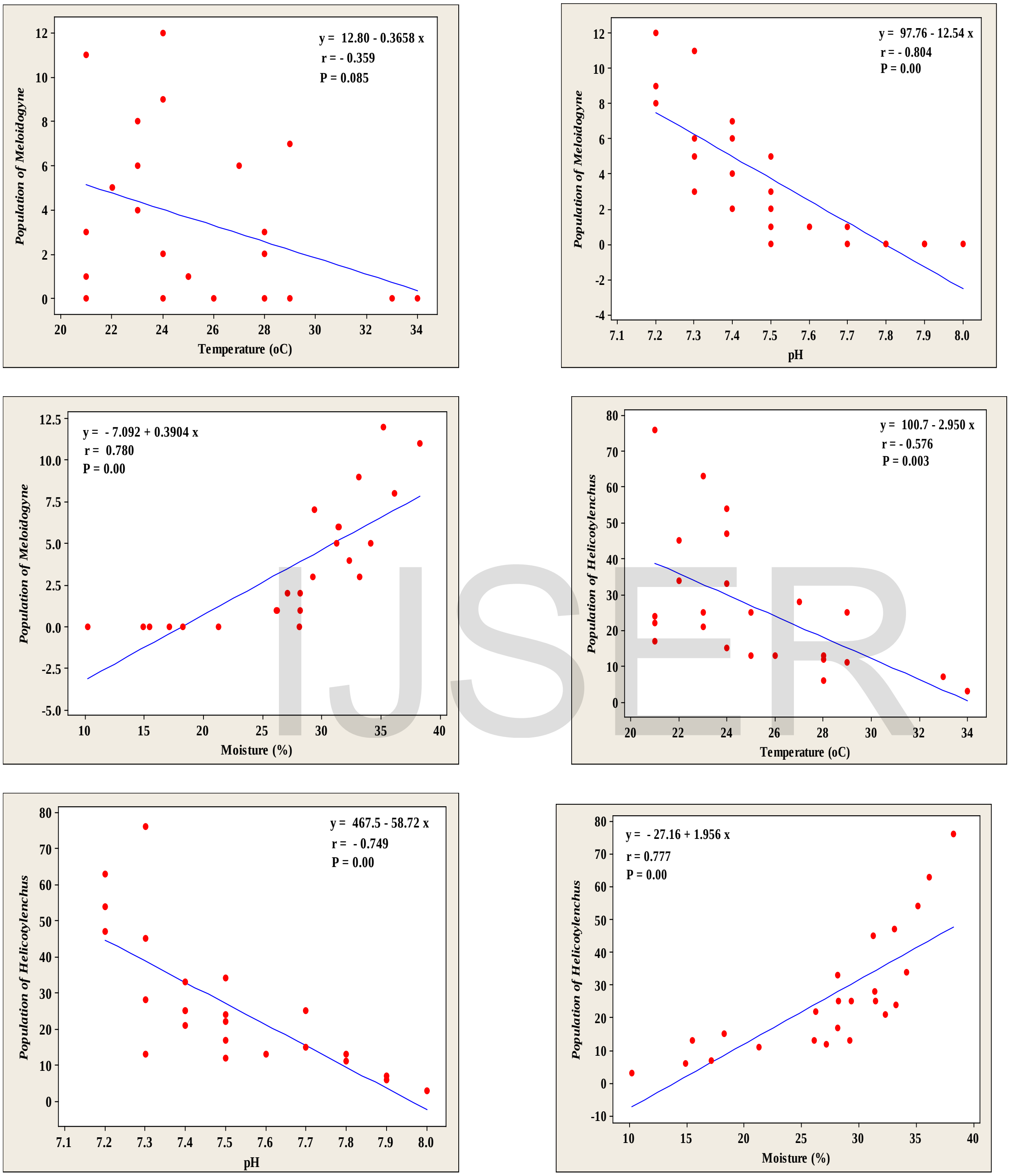


Figure: 3. Linear regression of Tylenchid and Dorylaimid population (genus *Pratylenchus* and *Eudorylaimus*) in relation with soil abiotic factors (as mentioned on X- axis) in Sillod mulberry field.

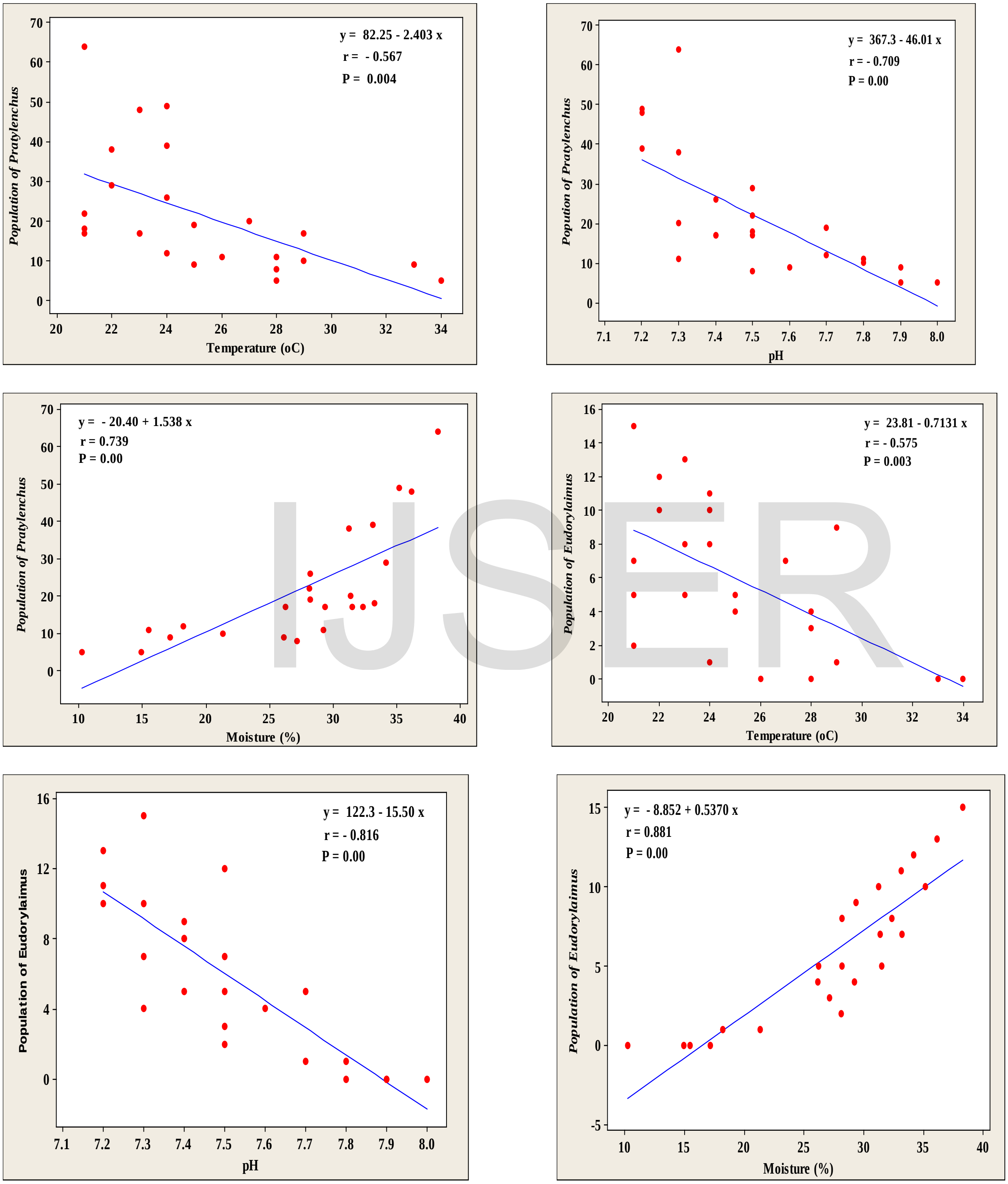


Figure: 4. Linear regression of Dorylaimid population (genus *Mesodorylaimus* and *Aporcelaimellus*) in relation with soil abiotic factors (as mentioned on X- axis) in Sillod mulberry field.

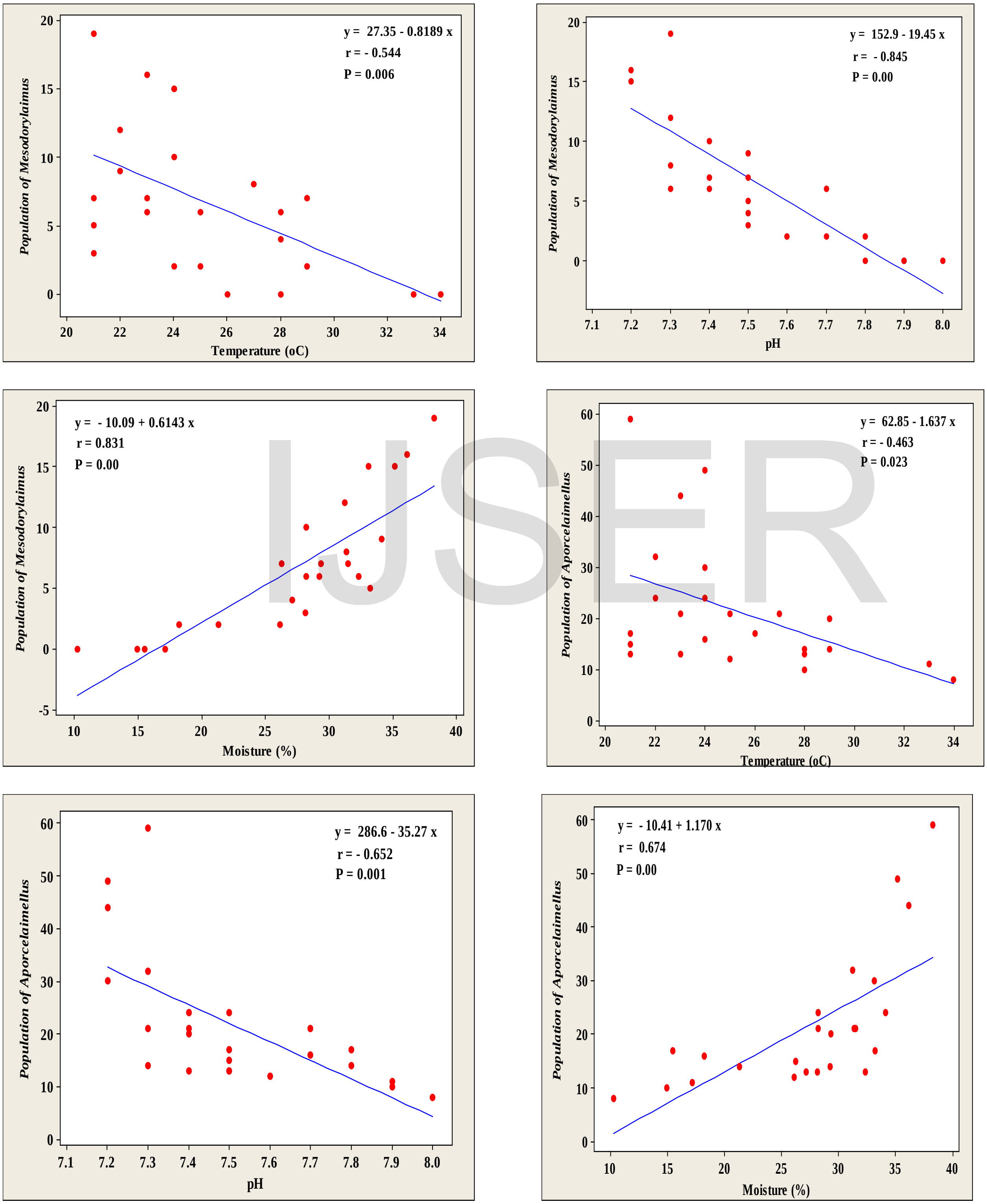
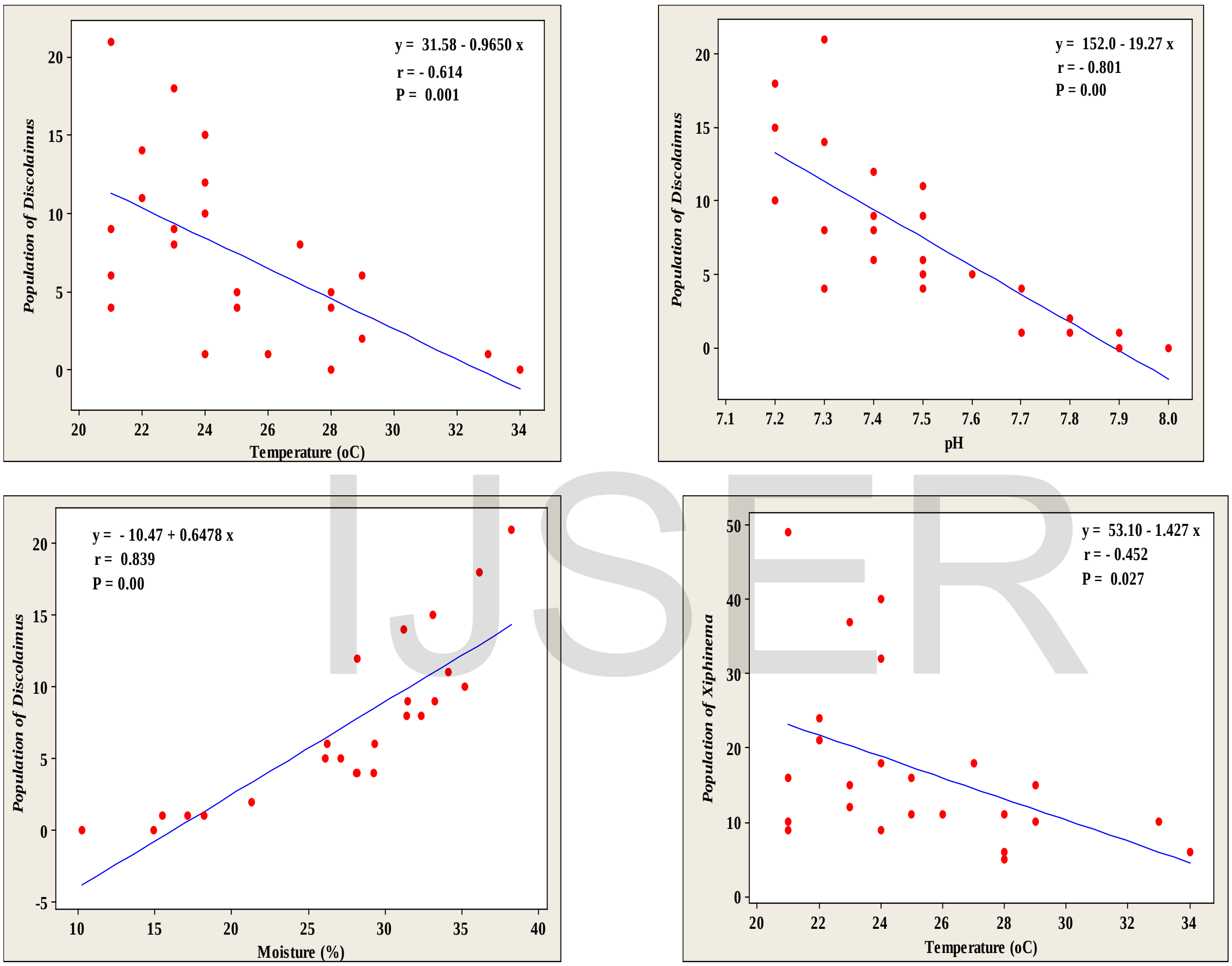
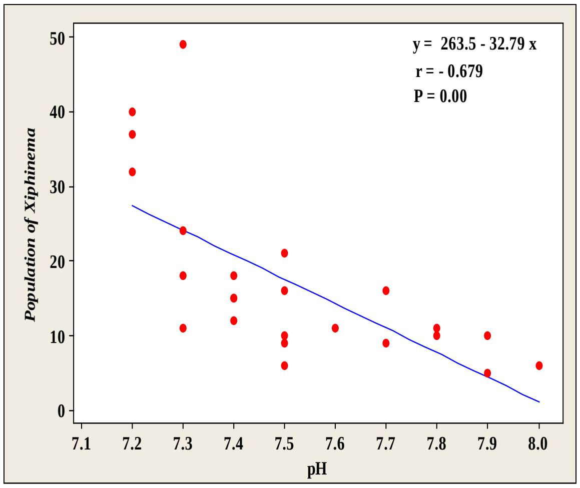
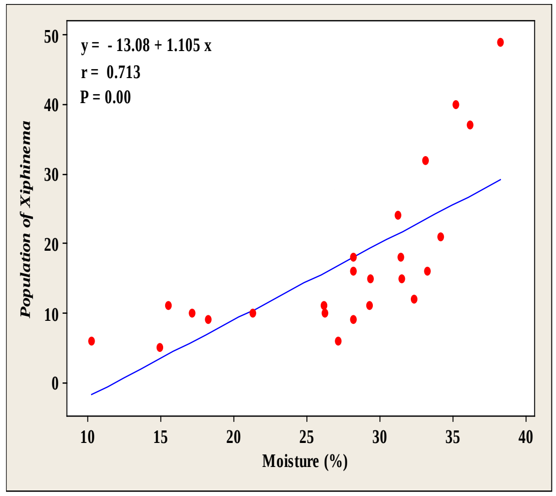


Figure: 5. Linear regression of Dorylaimid population (genus *Discolaimus* and *Xiphinema*) in relation with soil abiotic factors (as mentioned on X- axis) in Sillod mulberry field.




y = 263.5 - 32.79 x
r = - 0.679
P = 0.00
Population of Xiphinema
pH
0
10
20
30
40
50
7.1
7.2
7.3
7.4
7.5
7.6
7.7
7.8
7.9
8.0


y = - 13.08 + 1.105 x
r = 0.713
P = 0.00
Population of Xiphinema
Moisture (%)
0
10
20
30
40
50
10
15
20
25
30
35
40