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EFFECT OF SOME ECOLOGICAL PARAMETERS ON THE OCCURRENCE OF *HEXAMERMIS VISWAKARMA* DHIMAN, A MERMITHID PARASITOID OF *LEPTOCORIS AUGUR* (FABR.)

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ABSTRACT

H. viswakaram prefers loamy and sandy soil than the clay soil. At 90% R.H. minimum mortality 10% and survival rate 90% has been recorded. Cent percent R.H. is the optimum level at which maximum hatching 90% is recorded during rainy season. At 90% R.H. Maximum 90% hatching occurred which also increased parasitization percentage. Maximum 90% moulting in post parasitic juvenile nematods, too, occurred at 90% R.H. There is no marked effect of pH range 6.0 to 7.0 on the recovery of nematodes from the soil. At temp. 30 $\pm$ 2^0c the population of nematods *(H. viswakaram)* was found higher in sample area of a zone of soil.

KEYWORDS: Ecological parameter, *H. viswakarma*, soil, R.H., soil temperature.

INTRODUCTION

Leptocoris augur (fabr) (Heteroptera - Coroidae - Rhopalidae) is a pest of Kusum plant, *Schleichera oleosa Lour* (Sapindaceae) which in turn is parasitized by a Mermithid nematods *Hexamermis viswakarma* Dhiman. This nematode species was reported by Dhiman (1984). Only very few genera of Mermithid nematodes have been reported in India. Bindra and Kittur (1956) reported *Mermis indica* from the caterpillar of *Amsacta moorei*. *Agmamermis* was recovered from the rice stem borer *Tryporyza incertulis* by Rao (1964). Bhatnagar *et.al.* (1985) recorded mermithid from few insect species in India. Dhiman (1984) and Dhiman and singh (1996) rightly pointed out that it can be used as a biocontrol agent for the control of *L. auger* population. In present paper an endeavour is made to describe the effect of some ecological parameters on the occurrence of *H. viswakarama* in nature.

MATERIAL AND METHODS

The bugs (*L. augur*) were collected along with fresh leaves and seeds of Kusum plant from the field area of Horticultural Experiment and Training centre, Saharanpur by hand picking method during rainy season and were brought alive to the entomological research lab. M.S. College, Saharanpur in polythene bags. Collection was made randomly. Rearing of bugs was carried in hurricane glass lamp chimneys. The nematodes emerged out from the host body were collected with the aid of fine camel hair brush and were kept for rearing in double tray system as described by Dhiman and Ghayyur (1993). Ecological parameters effect on *H. viswakarma* population in nature was studied under the Kusum plant tree. Further experimental observation was made in laboratory.

RESULT

Effect of following parameters was considered on the occurrence of *H. viswakarma*.

(1) Soil- soil crumbs are formed by the aggregation of ultimate particles (clay, silt and sand) which vary in their relative amounts in different soil types. The particles are classified according to their sizes: <0.002 mm. are clay: 0.002 to 0.02mm silt and 0.02 mm. to 2 mm sand. Soil can be classified according to this arbitrary scale and range from clay soils to silty clays, loamy and sandy soils. The amount of colloidal material is sometimes included. The relationship between the textural characteristics of a soil and the distribution of nematodes is sometimes quite marked.

Hexamermis viswakarma prefers loamy and sandy soil then the clay soil because clay soils often have a lower permeability to water then sandy soils as their pores are smaller. Consequently clay soils tend to be wetter and less well aerated than sandy soils under the same climate conditions. The rate of larval emergence was greatest in the light sandy soil and least in heavy clays. Thus, pore size may influence emergence and measurements of the oxygen consumption of the different soils suggested that in clays there was a great consumption for oxygen which also reduced the rate of emergence.

The nematodes requires high relative humidity for hatching, movement etc. The moisture holding capacity is much lower in clay soil.

Thus, for *H. viswakarma* sandy and loamy soil has been observed suitable for their survival.

(2) Moisture Content

Moisture content is an important ecological parameter which influences the survivality and development of *H. viswakarma* sp.

(i) Effect of moisture content on the survivality of adult Hexamermis- adults of *H. viswakarma* are found in the soil of field area. During rainy season, i.e., late June to early October, number of adults and post-parasitic stages increases and reaches at the peak level due to increase in moisture upto 100%. During winter and summer, moisture percentage of the soil decreases which influences the survivability of nematodes, hence, their number decreases considerably (Table-1). During rearing of nemas in laboratory, the adults were kept in petridishes having sterile coarse sand and then subjected to temperature and humidity control cabinet at different relative humidity levels. Temperature was kept constant at 28 ± 2^0C. Data of the observation are presented in Table-2.

At zero percent R.H. 100% mortality was observed and adults died within few hours. At 25% R.H. mortality reduced to 85%. At 50% R.H. decrease in mortality percentage occurred upto 68%. At 75% R.H. survival rate increased further and mortality declined to 30%. At 90% R.H. mortality percentage decreases upto 10% and survival rate had gone to maximum level (90%). Thus, at 90% R.H. level minimum mortality was observed. Further, 100% R.H. had caused negligible increase in the death of nemas, i.e., 12%.

Aforesaid table also indicate that decrease or increase beyond the optimum R.H. results morality percentage in adults. The adults can tolerate low R.H. levels in comparison to other stages.

(ii) Effect of moisture content on oviposition, hatching and emergence of Hexamermis- During oviposition, mature eggs of *H. viswakarma* are laid down on the moist coarse sand in laboratory and in light sandy soil in field. Incubation period is greatly dependent on moisture content. Newly laid eggs were kept in petridishes in temperature and humidity control cabinet at 28 ± 2^0C and different R.H. levels. Hatching of the eggs was carefully examined under binocular microscope and the data are recorded in Table-3. Data showed that at zero, 25% and 50% R.H. eggs were dried after few hours to 2 days respectively. At 70% R.H. 30% hatching occurs with 19 days of incubation period. At high R.H. level, i.e., 90% hatching increased to 72% and at 100% R.H. 90% hatching occurred within 16

days of incubation period. Thus, 100% R.H. is the optimum level at which maximum hatching took place with minimum days of incubation period.

After hatching, the pre-parasites of *H. viswakarma* are highly sensitive to moisture and water content and only survive in high humidity. This moisture and water content helps in finding the suitable host by performing easy undulating movement on soil surface or on plant stem or leaves. However, in absence of moisture, these dehydrate and die due to less resistance cuticle (thin).

Thus, the high moisture content (during rainy months) increases the hatching and parasitization. In period between the two consecutive rainfalls, parasitization decreases many folds in absence of low moisture content.

(iii) Effect of moisture content on post parasitic juveniles- The post parasitic juveniles were kept in petridishes having moist sterile coarse sand and was subjected to different R.H. levels in temperature and humidity control cabinet at 28 ± 2^0C. The datas are presented in Table - 4.

The observations revealed that at 0.0% and 30% R.H. no post parasitic juveniles survived. At 50% R.H. moulting post parasitic occurred upto 35% within 28 days. At 75% R.H. 60% post parasitic survived while at 90% R.H. maximum 90% moulting took place in normal 23 days. At 100% R.H. moulting further decreased to 88% with 22days post parasitic period. 90% is the optimum R.H. level at which maximum moulting and minimum mortality occurs.

(3) Salinity or acidity

Effect of pH on the occurrence of adult nematodes as well as on the parasitization percentage was examined. For this, random soil samples of the study site area were taken by collecting the soil of 30x 30 x 30 cm area. The recovery of the nematodes was noted per soil sample and the pH of the sampled soil was determined by using the Beckmans pH meter as well as by Universal indicator (BDH). During the parasitization period (July to September) pH of haemocoelomic fluid of the nymphs, adult bugs and pulpy seeds of *S. oleosa* was also estimated using the BDH papers of different pH ranges.

The adult *H. viswakarma* population, though was recorded maximum at 7.0 pH but there is no marked effect of pH range 6.0 - 7.0 on the recovery of nematodes from the soil (Table-5). The pH of the haemocoelomic fluid of nymphs and adults of *L. augur* is recorded 5.0 and

both the stage of the host bug were observed equally parasitized. The pH of the pulpy seeds of *S. oleosa* on which the bug population feeds gregareously is observed highly acidic (3.5 to 4.0). It seems that parasitization occurs in acidic pH ranging from 4.0 to 6.0 (mean 5.0).

Further, after making these observations, effect of different pH levels on the survivality of post parasites was studied in laboratory. For this purpose, newly emerged post parasitic juveniles were kept in different petridishes having solutions of different pH ranges (4.5 to 8.5). The exposure time was given till their moulting into adult or upto their death. Test solutions consisted of distilled water containing 0.005 $MNaH_2PO_4$. The specific pH values were obtained by varying the percentage of salt solution. Since pH values moderated during the exposure period, hence, means were determined of each test container and recorded as the pH for the given petridish. The test was conducted at ambient temperature 28 ± 2^0C. The experiments were repeated and the datas are recorded in Table- 6.

Results of the experiments revealed that acidic pH from 4.5 to 6.9 has no significant differences in the survivality and moulting percenage of *H. viswakarma* sp. However, it is maximum at pH 7.1 which almost coincides with the pH of the soil of field area (7.0). Furthermore, increase in pH beyond 7.0 upto 8.4 though slightly decreased the survivality percentage but moulting still occurred.

Thus, it is clear that pH under normal conditions is not a good limiting factor in the occurrence of *H. viswakarma* and it can tolerate this wide range of pH due to the presence of thick cuticle, which is a characteristic feature of all parasitic nematodes.

(4) Soil temperature

Various factor contribute to the energy balance at the surface of the soil : the net radition (i.e., the different between incoming and outgoing radiation), the rate of heat transfer between the surface and the soil, the rate of heat transfer between the surface and the atmosphere and loss of heat by evaporation of water.

The transfer of heat in a dry soil is chiefly via the solid particles, but as water content increases the transfer of heat through the water phase becomes increasingly dominant.

In general terms, a wet soil has a smaller temperature gradients and a smaller rise in temperature than dry soil with the same heat input at surface.

All the stages of *H. viswakarma* except the parasitic stage occurs in soil. It has been noted that these stages migrate vertically in the sol profile in response to seasonal changes in temperature. Change in temperature and the steepness of the temperature gradient depend on soil moisture which quite independently influences the movement of nematodes.

To observe the vertical distribution of nematodes in soil in relation to temperature fluctuations, a sample area was marked of the size 30 x 30 x 30 cm. This sample area was further divided vertically into three distinct zones- A (upto 10 cm depth), B (10-20 cm. depth) and C (20-30 cm. depth). Samples were examined monthly for the presence or absence of nematodes. Soil temperature was also recorded.

Data of two consecutive years 2015 to 2016 were taken and depicted in table-7 which reveals that during rainy months, July to September, when the average temperature of soil reaches upto 30$\pm$ 2 ^{0}C, the population of nematodes is found in high number in 'A' zone of soil as the nematodes migrate upwards towards the surface of soil. During late October, the nematodes migrate downwards in the soil upto 20cm. deep. In summer months the nematodes further migrate downwards upto 30cm. deep in soil.

Thus, the migration of nematode *H. viswakarma* completely depends upon temperature as well as on moisture content of the soil as stated earlier. However, body cuticle offers resistance upto a certain limit but it can not withstand high temperature and low R.H. for a longer period.

Table- 1: EFFECT OF MOISTURE CONTENT IN THE OCCURRENCE OF *H. VISWAKARMA*

Months	Moisture content (in%) of soil		No. of Post parasitic in 5^2/metre area		No. of adults in 5^2/metre area	
	2015	2016	2015	2016	2015	2016
Jan	25.5	23	14	10	11	8
Feb.	31.6	28	17	20	16	17
March	45	44	15	11	13	11
April	52	54.8	12	14	13	12
May	61	65	20	25	22	21
June	75	78	32	37	31	35
July	87.3	83	72	68	70	62
Aug.	96	92	97	90	95	88
Sept	99	97	120	115	118	109
Oct.	82	78.7	68	59	70	59
Nov.	50.8	54	40	45	38	42

Dec.	35	38	31	40	30	32

Table- 2: EFFECT OF DIFFERENT R.H. LEVELS ON ADULTS *H. VISWAKARMA* (AT 28+2^{0}C) IN LABORATORY

No. of observations	R.H. (%)	Exposure time (in hrs.)	Mortality (%)
30	0	5	100
40	25	14	85
45	50	72	68
50	75	95	30
65	90	100	10
50	100	110	12

SD = 8.996

Optimum R. H. - 90%.

Table- 3 EFFECT OF DIFFERENT R.H. LEVELS ON INCUBATION PERIOD IN *H. VISWAKARMA* (AT 28+2^{0}C) IN LABORATORY

No. of eggs kept	R.H. (%)	Average incubation period (in days)	Hatching (%)
30	0	Eggs dried	Nil
45	25	Eggs dried	Nil
40	50	Eggs dried	Nil
50	70	19	30
55	90	17	72
60	100	16	90

SD = 7.084

Optimum R. H. - 100%.

Table: 4 EFFECT OF DIFFERENT R.H. LEVELS ON POST PARASITIC JUVENILE PERIOD IN *H. VISWAKARMA* (AT 28+2^{0}C) IN LABORATORY

No. of Post parasitic juvenile kept	R.H. (%)	Post parasitic period (in days)	Moulting (%)
30	0	Died after few hours	Nil
40	30	Died after 2 days	Nil
40	50	28	35
45	75	26	60
55	90	23	90
60	100	22	88

SD = 8.690

Optimum R. H. - 90%.

Table- 5EFFECT OF pH OF SOIL SAMPLES ON THE RECOVERY OF NEMATODES, *H. VISWAKARMA*

No. of soil sample	pH of soil sample	Nematodes recovered
A	7.0	20
B	6.7	15
C	6.1	8
D	6.5	10
E	6.3	3

SD = 4.498

Table- 6EFFECT OF pH ON THE MOULTING / SURVIVALITY OF POST PARASITIC JUVENILES OF *H. VISWAKARMA*

S. No.	Mean pH of the petridish	No. of Post- parasite juvenile kept	No. of adults moulted	Percentage of moulting/ survivality
1	4.5	10	7	70
2	5.0	22	17	77
3	5.7	20	16	80
4	6.5	28	21	75
5	6.9	25	21	84
6	7.1	30	27	90
7	7.5	35	26	74
8	8.1	40	24	60
9	8.4	35	20	57

Minimum moulting at pH - 8.4

Maximum moulting at pH - 7.1

(Average has been taken of 20 observations)

Table- 7EFFECT OF SOIL TEMPERATURE ON THE OCCURENCE OF *H. VISWAKARMA*

Months	Average temperature of soil		Population of nematodes					
			A		B		C	
	2015	2016	2015	2016	2015	2016	2015	2016
Jan	12	12.9	+	+	++	++	-	-
Feb.	15.2	16.0	+	+	++	++	-	-
March	21.1	20.5	+	+	+	++	+	+
April	24.6	25.1	+	+	+	+	+	+
May	28.0	29.3	-	+	++	++	+	+
June	30.0	30.2	+++	+++	+	+	-	-
July	32.0	31.8	+++	+++	-	-	-	-
Aug.	31.0	30.7	+++	+++	-	-	-	-
Sept	29.0	29.03	+++	+++	-	-	-	-
Oct.	28.3	27.0	+++	+++	++	++	-	-
Nov.	18.2	17.7	++	++	+	+	-	-
Dec.	14.0	13.2	++	++	+	+	+	-

- - Nil

+ - Less
+ + - Medium
+++ - More
(+) indicates presence of adults and post parasitic

DISCUSSION

H. viswakarma prefers loamy and sandy soil than the clay soil because clay soil often has a low permeability to water than sandy soils as their pores are smaller. The rate of pre parasitic emergence was greatest in the light sandy soil and least in heavy clays. Pore size of the soil also influences the emergence of nemas. Daim *et.al.* (1987) studied the effect of sand particle size on the production of pre parasites of *Romanomermis iyengari*. They obtained good production of pre parasites and post parasites with sand particles size 1.4 and 2.0 mm.

Subjection of *H. viswakarma* at 28 $\pm$ 2 ^{0}C and different R.H. levels has revealed 90% R.H. as optimum level for survival. Maximum 90% hatching with minimum 16 days of incubation period occurred when R.H. increased to 100%. High moisture and water content helps in finding the suitable host by performing easy undulating movements. Singh (1990) also recorded 90% optimum R.H. level for the survival of adults. Adult *H. viswakarma* population, though has been recorded maximum at 7.0 pH but there is no marked effect of the pH range 6.0 to 7.0 on the recovery of nematodes from soil. pH of haemocoelomic fluid of nymphs and adults of host *L. augur* was recorded 5.0 and both stages were equally parasitized. It seems that parasitization occurs in acidic pH range 4.0 to 6.0 (mean 5.0) but maximum moulting is recorded at pH 7.1 which almost coincide with the pH of soil of field area (7.0). Brown and Platzer (1978) observed infection of *Romanomermis culicivorax* in a pH range of 3.6 to 8.6 . In India Rao *et. al.* (1979) observed mortality of pre parasitic and adults of *Romanomermis* sp. in pH 7.5. Thus, there is no specific pH range for different mermithids.

All stages of *Haxamermis viswakarma* occur in soil except parasitic stage. These migrate vertically in soil profile in response to seasonal changes in temperature and the steepness of the temperature gradient depend on soil moisture which quite independently influences the movements of nematodes. During rainy months at average soil temp. 30$\pm$2 ^{0}C nematodes migrate upwards towards the surface of soil. During late October, the nematodes migrate downwards in the soil upto 20cm. deep. In summer month of May & June these further migrate downwards upto 30cm. deep in soil. Thus, the migration of nematodes completely depends upon temperature as well as on moisture content of the soil.

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