DISCUSSION
POPULATION ESTIMATION: *Tylenchorhynchus mashhoodi*

Effect of crops

*Tylenchorhynchus mashhoodi* was the dominant species occurring in high densities under all crops except garlic and sesame where it was numerically poor (Tables 7 and 8). Occurrence of this species in large numbers with the majority of crops studied demonstrates polyphagy of the species. Numbers increased with the growth of the host crops and this increase is statistically significant (Appendix Table I to VI). The rate of increase is more at the early stage of crop growth than later stages. With the maturity of the crops, nematode numbers declined. Under jute, paddy and wheat population showed one peak whereas under sugarcane the peaks were bimodal.

This dynamic behaviour of phytophagous nematode under the influence of plant growth was shown by Oostenbrink (1950) in *Heterodera rostochiensis* and by Mukhopadhyaya and Prasad (1969) in *Tylenchorhynchus* spp. Decline in the rate of population increase at higher densities could be due to intraspecific competition and other case of environmental resistance as pointed out by Oostenbrink (1966) but it seems partly to be the consequence of cessation of root production by the host plant at later stages because nematode numbers declined when the crop was sampled at maturity.

Of the crops studied, *T. mashhoodi* was recovered in largest numbers from sugarcane and least from sesame and garlic. Though
polyphagous, it showed some preference towards Graminae. Jute also as host crop, behaved similarly. Probably, it was the second preferred host of *T. mashhoodi* as seen from the results of present investigation. Oostenbrink (1966) obtained more numbers of *Tylenchorhynchus* in Oats (Graminae). Mukhopadhyaya and Prasad (1968) obtained maximum number of *Tylenchorhynchus* from wheat, maize and sugarcane and Haque and Mukhopadhyaya (1977) collected maximum number of the genus from sugarcane. Results of the present study are in agreement with these findings. Inhibitory effects of garlic and sesame has been discussed later separately.

**Effect of crop sequence**

The crop sequence Jute-Wheat-Sugarcane-Sugarcane at Bhedia supported on an average, 123,199 and 290 *T. mashhoodi* under jute, wheat and sugarcane respectively. In other words, the field at Bhedia contained, on an average, 204 nematodes per 100 cm$^3$ soil under crops.

Jute-Garlic-Sugarcane-Sugarcane rotation at Bahiri-1 contained 163,60 and 206 *T. mashhoodi* under jute, garlic and sugarcane respectively. In other words, the field contained 143 nematodes per 100 cm$^3$ soil under crops.

At Jaugram the Jute Fallow-Sesame-Sugarcane-Sugarcane sequence contained 260.43 and 94 *T. mashhoodi* under jute, sesame and sugarcane respectively. Thus, the field at Jaugram contained 132 nematode species per 100 cm$^3$ soil under crops.
The field at Bolpur-1 having Paddy-Fallow-Sugarcane-Sugarcane-sequence had 289 and 478 \( T. \) mashhoodi under paddy and sugarcane respectively. In other words, the field continued 383 nematode species per 100 cm\(^3\) soil under crops.

Sugarcane-Sugarcane-Fallow-Jute-Fallow sequence at Bahiri-2 contained 248 and 728 \( T. \) mashhoodi under jute and sugarcane respectively; or the field contained, on an average, 488 nematodes species per 100 cm\(^3\) soil under crops.

The field at Bolpur-2 having Sugarcane-Sugarcane sequence contained 1109 \( T. \) mashhoodi per 100 cm\(^3\) soil under sugarcane. However, when in the next year the field was partly treated with a plant product, nematode density came down to 228 per 100 cm\(^3\) soil; the details of which have been discussed later on.

In fields, where sugarcane was cultivated, it was observed that nematode population went high during May in the early vegetative stage of the crop and again during October in the late mid vegetative stage. Decline in nematode population started during June with the onset of monsoon and continued through July when rain water stagnated in the fields. After cessation of monsoon rains, population started increasing from August and through September it reached a peak during October. With the beginning of winter in November and completion of vegetative growth of the crop, population started declining and continued till harvest in January. Thus, under sugarcane, nematode population of the species reached peaks, that synchronized with plant growth, rainfall and temperature. Similar observations on population fluctuations of plant
nematodes has been made by Azmi (1990). Effect of rotation as well as growth period is significant (Appendix Tables II, III, IV, V, VI).

Abundance of Tylenchorhynchus mashhoodi was maximum in the field at Bolpur-2 and Bahiri-2 and minimum at Jaugram and Bahiri-1. In the field at Bolpur-2 monoculture of sugarcane was practised and that at Bahiri-2, sugarcane was cultivated for two successive years. Mukhopadhyaya and Prasad (1969) and Ticknova and Smirnov (1969) and Baranovskaya et al. (1978) reported that monoculture had more nematodes than the rotational plots.

Seasonal increase/decrease of T. mashhoodi population showed two peaks one in May and the other during October. Similar bimodal peaks for Tylenchorhynchus zaeae was obtained by Haque and Mukhopadhyaya (1977).

Fallow

Tylenchorhynchus mashhoodi

A fallow in between two crops is capable of reducing nematode number as was observed for T. mashhoodi in three cropping sequences (Table 10). However, if the duration of this fallow period is small, nematode population builds up again on availability of a suitable crop as was observed in the Paddy-Fallow-Sugarcane-Sugarcane sequence at Bolpur-1. On the contrary, if a fallow period is succeeded by an antagonistic crop like sesame, nematode population declines and reaches
a low level as was observed in the Jute- Fallow- Sesame- Sugarcane -Sugarcane sequence at Jaugram. Here, nematode population at the end of the fallow period was 95 per 100 cm$^3$ soil which further went down to 60 per 100 cm$^3$ soil when the field was sampled at the early stage of sesame. In Bahiri-2, at harvest of sugarcane, *T. mashhoodi* population per 100 cm$^3$ soil was 420 that came down to 225 per 100 cm$^3$ at the onset of fallow. At the end of the fallow period that continued for three months, nematode populations came down to 92 per 100 cm$^3$ soil which rose to 110 per 100 cm$^3$ soil in the early stage of the next crop jute. At prior harvest of jute, nematode population increased to 275 per 100 cm$^3$ soil which came down to 122 per 100 cm$^3$ soil during fallow in the next month. At the end of fallow after three months, nematode population was reduced to 75 per 100 cm$^3$ soil. In other words, if the fallow be allowed or can be extended for a larger period, nematode population progressively decreased. Saxena *et al.* (1977) studied population dynamics of *Tylenchorhynchus brassicae* under many crops and commented that nematode population went low during fallow.
POPULATION ESTIMATION: Hoplolaimus indicus

Tendency of increase in population of the H. indicus was similar in the crops studied. In the beginning, during the vegetative stage of crop growth, the nematode species multiplied at faster rate and this rate of population increase slowed down when the crop was advancing towards maturity (Tables 11 to 17). This dynamic behaviour of Hoplolaimus indicus and density of the nematode species under different hosts is discussed below.

Under jute

In the month of July when jute was in the mid vegetative stage, the crop cut off new roots, nematode numbers increased at a faster rate because there were more feeder roots. Between August and September, the host entered into the flowering stage when availability of new roots became lesser and this was reflected in the relatively slower rate of nematode increase. After September, when the crop was maturing and nearing harvest, nematode population showed signs of declining. This decline in population was evidenced in October when the crop was harvested. Effect of growth period in influencing nematode population is statistically significant (Appendix Table VII). Oostenbrink (1966) attributed roles of many factors for this behaviour and stressed that mainly availability of feeder roots was the principal factor.
Under paddy

In July and August when paddy was in tillering stage, nematode numbers increased at a faster rate because the host was cutting off new roots. When paddy entered into the reproductive phase in the month of September and October, availability of new roots became lesser, consequently, there was a slower rate of nematode multiplication from September to October. In November when paddy was heading towards maturity and attaining harvest nematode population was declining. This is why an appreciable decline in nematode population was noticed from November to December (Table 12). Similar increase in *H. indicus* population under paddy was observed by Ramana and Rao (1976) who commented that absence of lignification and accumulation of starch in the roots favoured nematode multiplication. Result of this investigation is in agreement with the above finding.

Under wheat

As was observed for jute and paddy, the nematode species under wheat behaved in the same way with an enhanced rate of population increase at the initial stage of crop growth and later at a slower rate. With the completion of vegetative stage when the plants started contributing to its reproductive sink, production of new roots stopped which in turn influenced nematode multiplication. Ultimately at maturity of the crop nematode numbers declined when the root system was drying up (Table 13). Mukhopadhyaya and Prasad (1969) obtained population increase of similar nature in *Hoplolaimus indicus* under wheat.
Under sugarcane

Under sugarcane population increase was bimodal, the species exhibited one peak in May and the other in October (Table 16). Density of the population became lower during June and July when the field received monsoon rains. With the cessation of rains, nematode population again started multiplying with the fresh growth of the host crop and this continued till the winter set in. During winter at maturity of the crop and at harvest population declined appreciably. Effect of growth period in influencing nematode population is statistically significant (Appendix Tables VIII, IX, X, XI, XII).

Effect of crop sequence

The crop sequence Jute-Wheat-Sugarcane-Sugarcane at Bhedia supported on an average, 171,136, and 183 *Hoplolaimus indicus* under jute, wheat and sugarcane respectively. In other words, the Bhedia field contained on an average 163 nematode species per 100 cm\(^3\) soil under crops.

Jute-Garlic-Sugarcane-Sugarcane rotation at Bahiri-1 contained 145,39 and 125 *H. indicus* under jute, garlic and sugarcane respectively. In other words, the field contained 103 nematode species per 100 cm\(^3\) soil under crops.

At Jaugram the Jute-Fallow-Sesame-Sugarcane-Sugarcane sequence contained 126,23 and 115 *H. indicus* under jute, sesame and sugarcane respectively. Thus, the field at Jaugram contained on an average, 88 nematodes per 100 cm\(^3\) soil under crops.
The field at Bolpur-1 having Paddy-Fallow-Sugarcane-Sugarcane sequence had 87 and 164 \textit{H. indicus} under paddy and sugarcane respectively. In other words, the field contained 125 nematode species per 100 cm$^3$ soil under crops.

Sugarcane-Sugarcane-Fallow-Jute-Fallow sequence at Bahiri-2 contained 122 and 221 \textit{H. indicus} under jute and sugarcane respectively, or the field contained, on an average, 171 nematode species per 100 cm$^3$ soil under crops.

The field at Bolpur-2 having Sugarcane-Sugarcane crop sequence contained 500 \textit{H. indicus} per 100 cm$^3$ soil under sugarcane.

Under fallow

As was observed for \textit{T. mashhoodi}, \textit{Hoplolaimus indicus} also showed the same trend of population reduction under the influence of fallow (Table 17). Number of nematode species recovered under paddy at harvest was 62 per 100 cm$^3$ soil that came down to 35 per 100 cm$^3$ with the onset of fallow in January. A further reduction in number was observed in February but population rose rapidly again when the crop sugarcane was transplanted in the same field. \textbf{Thus, with the availability of the host crop, nematode population built up again.} However, the picture was somewhat different in the Jute-Fallow-Sesame-Sugarcane-Sugarcane sequence at Jaugram. From jute, population came down to a significant level under fallow. At the end of the fallow period when sesame was planted, there was a further reduction in \textit{H. indicus} population. This was possible because sesame depressed nematodes instead of promoting its population. Under the
sequence of Sugarcane-Sugarcane-Fallow-Jute-Fallow at Bahiri-2 nematode population rose under sugarcane and jute came down during periods of fallow. Thus a fallow between two crops is capable of reducing nematode population as observed for this species also. Chawla and Prasad (1973a, 1973b), while studying the effect at multiple cropping of plant nematodes, observed that nematode population declined where rotation included a fallow.
VERTICAL DISTRIBUTION: *Tylenchorhynchus mashhoodi*

Soil samples were collected from four different depths viz. 0 to 5, 5 to 10, 10 to 15 and 15 to 20 centimetre soil layers and nematode number recovered during different months under crops have been presented in Tables 18A to 23F.

An examination of the Tables 18A to 18D revealed that under jute *T. mashhoodi* preferred to inhabit the soil depth of 0 to 10 centimetre. Combining the population of the nematode species from all jute fields, it was observed that 79 per cent of the population was recovered from aforesaid (0 to 10 centimetre) soil layer and the rest 21 per cent abounded the 10 to 20 centimetre layer. In other words, nearly four fifth of the population was recovered within a depth of 10 centimetre and the rest one fifth of the population inhabited the deeper (10 to 20 centimetre) layer.

Under paddy, nearly 75 per cent of *T. mashhoodi* was recovered from 0 to 10 centimetre soil layer and the remaining 25 per cent was recovered from 10 to 20 centimetre soil depth. Maximum numbers were recovered from the second layer i.e. 5 to 10 centimetre deep which contained one and half times the number contained by the topmost layer. Again, the third layer (10 to 15 centimetre) contained nearly double the numbers than the fourth or the deepest layer. An overall examination of Table 19, showed that three fourth of the population was recovered from 0 to 10 centimetre layer and the rest one fourth from 10 to 20 centimetre soil depth.
The nematode species under wheat was distributed more or less in the same pattern as was observed for paddy. Wheat soils contained nearly 71 per cent of the population in the 0 to 10 centimetre soil depth while the rest 29 per cent of the population was recovered from 10 to 20 centimetre soil layer (Table 20). As was observed for paddy, here also, the second soil layer namely, 5 to 10 centimetre soil layer contained one and half times the numbers than the topmost layer. Again, the third layer, i.e. 10 to 15 centimetre supported double the number of nematodes compared with the deepest layer.

Garlic contained, in the second layer, more than one and half times the number than that of the top layer (Table 21). In fact, this second layer contained the maximum number of nematodes. The third layer contained double the numbers than that of the fourth layer; this last mentioned layer contained the least number of nematodes. When populations of the first two layers were pooled, it was observed that 0 to 10 centimetre soil depth contained 72 per cent of the population and the 10 to 20 centimetre soil layer contained 28 per cent of the total numbers.

*T. mashhoodi*, under sesame, behaved in the same manner as was observed for the previous crop (Table 21). The first two layers i.e. 0 to 5 and 5 to 10 centimetre soil layers contained nearly 75 per cent of the nematodes and the deeper layers 10 to 15 and 15 to 20 centimetre contained a little over 25 per cent. The second layer (i.e. 5 to 10
centimetre) contained double the number of nematode than that of the topmost layer. Again, the third layer (10 to 15 centimetre) contained double the numbers than that of the deepest layer (Table 22).

Under sugarcane, maximum concentration of *T. mashhoodi* was observed in the 5 to 10 centimetre soil layer which contained a little more than 40 per cent population (Table 23A to 23F). Next this soil layer, the surface layer i.e. 0 to 5 centimetre depth contained nearly 30 per cent of the nematode species. In other words, the top 10 centimetre soil layer contained more than 70 per cent of the nematode species. The third depth i.e. 10 to 15 centimetre soil layer contained 21 per cent of the population and the deepest 15 to 20 centimetre layer contained only a little more than 8 per cent of the population. Thus, these two layer 10 to 15 and 15 to 20 centimetre depths together contained a little more than 29 per cent of the population.

Distribution of a plant nematode in cultivated soils is mainly controlled by three principal factors viz. the availability of feeder roots in that particular soil layer, climatic condition in the rhizosphere zone and a combination of these two factors. When climatic conditions were favourable and feeder roots available, *T. mashhoodi* preferred to inhabit the 0 to 10 centimetre soil depth wherefrom more than 73 per cent population was recovered. Taken all crops together, a little more than 43 per cent of the population was recovered from 5 to 10 centimetre soil layer and nearly 30 per cent from the 0 to 15 centimetre depth. In other words, the second layer contained nearly one and half time the population than that recovered from the top layer. The deeper layers viz. 10 to 15 centimetre and 15 to 20 centimetre soil
depths contained respectively a little more than 18 per cent and 8 per cent of the population or the deepest layer contained less than half the numbers than that of the next top layer.

From the foregoing observations, it may probably be said that nearly three fourth of the population of *T. mashhoodi* is distributed in the top 10 centimetre soil layer and only one fourth of the nematode species is distributed within a soil depth of 10 to 20 centimetre. Thus, the preferred depth of habitation of *T. mashhoodi* under host crops was the top 10 centimetre soil layer. Wallace and Greet (1964) obtained this concentration at 5 centimetre depth for *Tylenchorhynchus icarus*. Yuen (1966) obtained most of the nematode from 6 to 8 centimetre depth, Mukhopadhyaya and Prasad (1968) obtained most of the *Tylenchorhynchus* spp. from the 0 to 10 centimetre soil depth and Ovechnikov (1972) obtained maximum population of *T. dubius* from 0 to 20 centimetre layer. Results of the present investigation are in agreement with these findings.
VERTICAL DISTRIBUTION: *Hoplolaimus indicus*

The preferred depth of habitation of *Hoplolaimus indicus* under jute was 5 to 15 centimetre soil depth wherefrom more than 68 per cent of the population was recovered. The 10 to 15 centimetre soil layer contained nearly one and half times the population compared with that of 5 to 10 centimetre layer. The top layer i.e. 0 to 5 centimetre and the deepest layer 15 to 20 centimetre each contained, on an average, around 15 per cent of the population. Difference in population in these two layers was not remarkable, the deepest layer containing a few more (Tables 24A to 24D).

Under paddy maximum number of *Hoplolaimus indicus* was recovered from 5 to 15 centimetre soil layer. The two layers i.e. 5 to 10 and 10 to 15 centimetre together contained 68 per cent of the population, while, the top layer and the deepest layer contained the rest 32 per cent. Maximum population was obtained from 10 to 15 centimetre soil layer which contained nearly one and half times the population supported by the 5 to 10 centimetre layer. Number of nematodes contained by top layer and deepest layer did not differ appreciably.

Population of *H. indicus* under wheat presented more or less a picture similar to that of paddy and jute. Under wheat, nearly 68 per cent of the population was obtained from 5 to 15 centimetre soil layer, maximum number being contained in the 10 to 15 centimetre layer. As was observed earlier the differences between the topmost layer and the deepest layer was not great so far as *H. indicus* population is concerned.
The pattern of distribution of \textit{H. indicus} in relation to soil depth was more or less the same under garlic and sesame. Under these two crops, a little more than 67 per cent of the total population was recovered from 5 to 15 centimetre layer; 10 to 15 centimetre layer containing more than one and half times population than that of 5 to 10 centimetre layer. Under garlic not much difference existed in population recovered from the topmost layer and the deepest layer but under sesame these difference was noticeable, the deepest layer containing a few more nematodes. Same was true for sugarcane also, the crop containing a few more nematodes in the deepest layer compared with the topmost layer. Like garlic and sesame, sugarcane contained a little more than 67 per cent of the total population in the 5 to 15 centimetre layer.

When all the six crops were taken into account, it was observed that population recovered from 5 to 15 centimetre layer was 67 per cent of the total population, 10 to 15 centimetre containing 41 per cent i.e. one and half times of the population contained by 5 to 10 centimetre layer. The top layer contained 15 per cent and the deepest layer contained 18 per cent of the nematodes. Mukhopadhyaya and Prasad (1969) observed that the peak of distribution of \textit{Hoplolaimus} was 10 to 20 centimetre soil layer. They also noted that there was not much difference between the numbers recovered from the top and deeper layer. Ramana and Rao (1976), in rice soils, obtained concentration of \textit{H. indicus} in the plough layer i.e. up to 15 centimetre depth. Sarkar
(1988) observed that *H. indicus* preferred to inhabit the 5 to 15 centimetre soil depth in cultivated soils. Saha (1991) commented that *H. indicus* remain concentrated in the 5 to 15 centimetre soil layer under crops but under grasses the zone of concentration was 5 to 10 centimetre soil depth. However, Saha (1991) obtained significant difference in population between the topmost and deepest layer in cultivated soils. Results of the present investigation is in agreement with the findings of the earlier workers except that of Saha who obtained significant differences between the population of the top and deeper layers.
Garlic as one of the crops was cultivated in the crop sequence Jute-Garlic Sugarcane-Sugarcane in the field at Bahiri-1. Unlike other crops (except sesame), garlic did not promote nematode multiplication but depressed it as evidenced from the lower number of nematodes recovered under it. In the early stage of garlic growth, when the field was sampled, it was noticed that there had been 56 per cent reduction in nematode population compared with that obtained from the previous crop jute at harvest. Under garlic, samples were taken three times and when population of the first sampling date in December was compared with that of the last taken during February, it was observed that reduction by 37 and 42 per cent occurred for *T. mashhoodi* and *H. indicus* respectively.

Sukul *et al.* (1974) applied ethanol of some edible crops on nematodes and observed that only garlic extract was nematicidal when it was allowed to act upon for twentyfour hours. Similarly, Nath *et al.* (1982) reported nematicidal properties of garlic. Results of the present experiment are agreement with these findings.

Sesame was cultivated at Jagram under the crop sequence Jute-Fallow-Sesame-Sugarcane--Sugarcane. When samples were taken during fallow and thereafter at the early growth stage of sesame, it was observed that 36 per cent reduction in nematode population occurred within an interval of a month. Later on, soil samples, under sesame was collected thrice and it was noticed that there had been respectively 17 and 33 per cent reduction in *T. mashhoodi* and *H. indicus* population in
the pod formation stage of the crop. After this, though number of *T. mashhoodi*, went low, that of *H. indicus* remained constant. Haque and Mukhopadhyaya (1977) obtained, in rotational fields, fewer number of *Tylenchorhynchus zeae* under sesame and garlic. While reporting nematotoxicity of vegetable oils. Miller (1979) pointed out that linseed inhibited nematode populations of *T. dubius* and *Pratylenchus penetrans*. Similarly, Mukhopadhyaya and Chakrabarti (1985) observed that linseed inhibited. *T. zeae*, sesame, as observed in the present investigation, acted like linseed. Probably, the crops garlic and sesame release some toxicant or toxicants that retard nematodes to increase in number.

Dried corm powder of wild arum *Typhonium trilobatum* proved to be nematicidal when it was applied in the field at Bolpur-2 where sugarcane is cultivated in monoculture. Application of the powder at 625 kg per hectare could control more than 82 and 58 per cent population of *T. mashhoodi* and *H. indicus* respectively, in other words, more than 70 per cent control was achieved with a simultaneous increase in cane yield by more than 13 per cent. Mukhopadhyaya et al. (1980) applied 0.6 gram corm powder per kg soil and observed that the powder could save two successive crops from root-knot attack. In the present experiment also on application of the powder could prevent population build-up for two successive years in the sugarcane field concerned. Chattopadhyay and Mukhopadhyaya (1989a) observed that *T. trilobatum* not only acted as a potential nematicide but it was a growth promoter also. Results of these findings are in agreement with those of the present investigation.
PATTERN OF DISTRIBUTION

In populations where the individuals are distributed at random, i.e., are independent of each other, the variance ($S^2$) at each population density is equal to the mean ($M$) (Taylor, 1961). Individuals in natural population are not, however, independent of each other, mutual attraction leads to aggregation which makes variance more than the mean ($S^2 > M$). This property of natural population to show some degree of aggregation is exhibited by the plant nematodes (Mathias, 1969; Perry, 1983; Boag and Topham, 1984; Mc Sorley et al. 1985; Mukhopadhyaya and Sarkar, 1990). The available informations suggested that, when Taylor's Power Law was applied to nematodes, distinct differences were observed between species. Boag and Topham (1984) remarked that the amount of aggregation of *Longidorus elongatus* apparently differed according to the distance between sampling points and was probably influenced by soil type. Mc Sorley et al. (1985) determined the number of cores necessary to estimate the population densities of nematodes for a particular plot size. Gaur et al. (1988) obtained higher $b$ value with a concomitant increase in plot size and Mukhopadhyaya and Sarkar (1990) obtained differences in aggregation with regard to nematode species and field conditions. The $b$ values of a particular species varied greatly under the influence of host crops as well as in their absence.

Results of the present investigations indicate that with the growth of the host crop sugarcane, there had been a concomitant increase
in nematode populations and at this time nematode distribution tended to be dispersed. In September-October values of variance were, in general, lower than their respective means, indicating thereby the distribution is tending to be random. Of the six fields sampled, nematode populations relatively were greater at the fields at Bolpur-1, Bahiri-2 and Bolpur-2. In these fields, $b$ values were comparatively lower, around 1.00. In the other three fields Bhedia, Bahiri-1 and Jaugram $b$ value were slightly higher. After application of the pesticide in the field of Bolpur-2, when nematode numbers decreased, $b$ values became larger. Thus, nematode density has a bearing on the aggregation of the species. With the growth of the host, nematode density increased and nematode distribution tended to be dispersed consequently greater number of nematodes could be recovered from the sampling sites. Consequent on pesticide application, nematode number decreased, their distribution become more patchy, as a result of which they were recovered from less number of sampling sites, giving high $b$ values. Results of the present experiment indicate that density of a species has a bearing of the pattern of its distribution. These findings are not of variance with Taylor's hypothesis that $b$ value is constant and species specific, since it is recognised that $b$ values is dependent on the interaction between the species and its environment (Taylor, 1971; Banerjee, 1976). Moreover, the stability of $b$ value under different agronomic conditions with respect to a plant nematode is yet unknown. Probably, for a plant parasitic nematode species any statement on its $b$ value should qualify by a comment on the nematode density.
MORPHOMETRIC STUDIES: Tylenchorhynchus mashhoodi

Values of morphometric characters and ratios obtained from measurements of individual presented in Table 43 suggests that morphological characters of the nematode species were influenced by hosts. Results of these measurements are discussed characterwise below.

Body length

Body length was maximum in the females under sugarcane and minimum under sesame. Individuals of a particular sex were relatively longer under sugarcane, paddy, jute and wheat and shorter under garlic and sesame. On an average, females were longer than males. Range of variation was also greater in case of females than the males. Sugarcane, paddy, jute and wheat not only supported numerically more individuals but nematodes recovered from these hosts were also larger in size; thus hosts played a significant role in influencing the length of T. mashhoodi. Similar observations on host influencing nematode length were reported by Rashid and Khan (1976), Tarte and Mai (1976). Olowe and Corbett (1984a) for Pratylenchus spp. Das and Mukhopadhyaya (1985) and Pant et al. (1985) observed similar results for Tylenchulus semipenetrans and Meloidogyne incognita respectively.

In general, it was observed that males exhibited lesser range of variation in body length. While the difference between the maximum and minimum values in the females under sugarcane and paddy were 90 and 85 respectively, these were 45 and 47 respectively for males. Same was
true for other hosts also where range of variation in males is much smaller. This lesser range of variation in males was reported by Rashid and Khan (1976) and Saha (1991). It appears that body length exerted its differential effect on the two sexes.

Greatest body width

Greatest body width was maximum in the females under sugarcane (25 µm) and minimum under garlic and sesame (19 µm). Males under sugarcane had an average body width of 21 µm and under garlic and sesame males were 16 µm wide. As was observed for body length, greatest body width was influenced by the hosts; preferred hosts supporting longer as well as wider nematodes or in other words, healthier individuals. Similar observations on morphometrics of other nematode species under different hosts nutrition were made by Pant et al. (1985).

'a' ratio

Since individuals recovered from sugarcane, paddy and jute were wider, they had comparatively lesser 'a' values than those recovered from the remaining crops. Relatively slender females and males recovered from garlic and sesame exhibited somewhat higher 'a' values.

Body length was found to be correlated with greatest body width. Hence correlation coefficient was calculated between the body length and greatest body width. It was found that value of 'r' was positive and significant (r=0.735). In other words, these two characters exhibited positive allometric growth, hence the allometry of a pair of characters
used to form the 'a' ratio renders this value useful for taxonomic purposes.

Stylet length

Length of stylet showed variations of lesser degree between the two sexes but some degrees of variation existed within a sex among the crops. Females, in general, had longer stylet than males though the range of variation was small. Stylet length was shorter particularly under sesame and garlic. In other words, conditions that induced small body size also tended to produce shorter stylet though the difference was not noticeable as this character is concerned. Olowe and Corbett (1984b) obtained little difference in stylet length in Pratylenchus spp.

LOJ

Values of LOJ (length from the anterior end upto oesophago-intestinal junction) was higher in the individuals having larger body size. In other words, increase in body length and increase in the anterior portion had been proportionate on an average, body length was about 5 times the respective LOJ values. Das and Mukhopadhyaya (1985) reported similar variation between body length and neck length for Tylenchus semipenetrans. Results obtained from the measurements of T. mashhoodi indicate the presence of allometric growth between the body length and LOJ. Correlation coefficient calculated between the body length and LOJ value revealed that value of r was positive and significant (r=0.944).
'b' ratio

Mean 'b' values fluctuated within a small range and apparently did not show any relationship either with host crops or sex. Parameters contributing 'b' ratio, i.e. body length and LOJ, especially the body length differed significantly under hosts and sex; yet 'b' failed to reach the level of significance. It means that though the computant value (L) differed significantly, the effect was diluted to nonsignificant difference in the computed value ('b' ratio). Thus Chawla and Yadav's (1982) contention i.e., significant change in the computant value may not be reflected in the ratio holds good in the present work.

Excretory pore percentage

Position of excretory pore in relation to body length was, in general, some what anterior in females compared with males except for the individuals recovered from paddy and garlic where its position was same in both the sexes indicating thereby that this morphological character did not change its position with a change in the hosts or any other agronomic practice. Similar observations were made by Azmi and Jairajpuri (1976) for Helicotylenchus indicus and by Das and Mukhopadhyay (1985) for Tylenchulus semipenetrans.

Tail length

Like body length, tail length also varied but not to that extent as the former parameter did. Largest tail (60 µm) was obtained from
these individuals recovered under sugarcane and smallest from those recovered from garlic and sesame or individuals having larger body size possessed longer tails. In other words, conditions that induced small body size (e.g. host crop) also tended to produce small tails.

Correlation coefficient calculated between body length and tail length revealed that a positive correlation existed between the two (r=0.694) which is an indication of allometric growth. Waliullah (1985) obtained such relationship in two Tylenchid species.

'c' ratio

This ratio did not differ either between the sexes or among the hosts. Though body length and tail length varied in similar manner and showed positive correlation between them, both of them contributing to the 'c' ratio, yet the ratio failed to show any significant difference. In other words, significant changes in the computant values was not reflected in the ratio.

V% and T%

Under the influence of a host species position of vulva and length of testis differed within a small range and appeared to be correlated with body length. Individuals recovered from sugarcane were longest and their V% and T% values were highest. On the other hand, individuals recovered from garlic and sesame had minimum body length, consequently V% and T% values of these individuals were lower. However,
these higher and lower V% and T% values fluctuated within a small range indicating thereby that the reproductive organs are relatively stable compared with other morphometric characters. Similar observations were made by Bird and Mai (1967), Evans and Fisher (1970), Fisher et al. (1984) and Ray et al. (1985) for other nematode species.
Values of morphometrical characters and ratios obtained from measurements of individuals presented in Table 44 suggests that morphological characters of *Hoplolaimus indicus* were influenced by hosts. These are discussed characterwise below.

**Body length**

Body length was more or less the same in females (1170 µm) and males (1182 µm) under sugarcane where the individuals attained the maximum size. Shorter males and females were recovered from garlic and sesame where females had, on an average, a body length of 1075 µm and males 1080 µm. In general, males were slightly longer than the females (all crops taken together) (Table 44). Though the difference in body length between the sexes was marginal but the hosts played a significant role in influencing length of the nematode species. Similar observations on *Hoplolaimus indicus* was made by Chawla and Yadav (1982).

**Greatest Body Width**

Greatest Body width was maximum in both the sexes under sugarcane and was minimum in the individuals recovered from garlic and sesame. Greatest body width did not differ greatly between the two sexes under any crop.

As was observed for body length, greatest body width was also influenced by the hosts; preferred hosts supporting wider nematodes or healthier individuals.
'a' ratio

Since individuals recovered from sugarcane were wider, they had comparatively lesser 'a' value than those recovered from garlic and sesame where individuals were comparatively slender. Body length was found to be correlated with the greatest body width. Hence correlation coefficient was calculated between these two variables and it was found that the value of r was positive and significant (r=0.684). In other words, these two characters exhibited positive allometric growth.

Stylet length

Length of stylet was maximum in the individuals recovered from sugarcane and jute and minimum from those recovered from garlic and sesame. Females had consistently longer stylet than males. It appears true that the conditions that induced small body size also tended to produce shorter stylets but the magnitude of variance in this parameter between the two sexes or among the hosts is rather small. Earlier workers also obtained little difference in stylet length for other nematode species (Rashid and Khan, 1976, Olowe and Corbett, 1984b).

LGO

Values of LGO (distance from anterior end to the posterior end of oesophageal glands) was higher in the individuals having larger body size. In other words, increase in body length and increase in the anterior portion had been proportionate. On an average, body length was about 7 times the respective LGO value.
Correlation coefficient calculated between the body length and LGO value revealed that the value of 'r' was positive and significant ($r=0.817$). This indicates the presence of allometric growth between the two characters concerned. Chawla and Yadav (1982) reported similar variation between body length and neck length for *Hoplolaimus indicus*.

**b' ratio**

Mean $b'$ value fluctuated within a small range and did not show any appreciable difference either between the sexes or among the crops. Parameters contributing to $b'$ ratio i.e., body length and LGO differed under different hosts but values of $b'$ did not differ significantly indicating thereby an increase in LGO value was proportional to the body length.

**Excretory pore percentage**

Position of excretory pore in relation to body length was somewhat anterior in males compared with that in females but this difference was not great, indicating thereby that this character did not change its position under the influence of hosts. Similar observations was made by Azmi and Jairajpuri (1976) for *Helicotylenchus indicus*.

**Tail length and 'c' ratio**

*Hoplolaimus indicus* did not show any great differences in tail length either among the crops or between the sexes though, in general, it was observed that females had longer tails. Individuals having
longer body did not necessarily possess longer tails. Moreover, though males were slightly longer than the females, they were observed to have shorter tails.

Variation in 'c' ratio was not consistent with the body length probably because increase/ decrease in body length was not consistent with a concomitant increase/ decrease in tail length. Values of 'c' ratio were somewhat larger in males.

V% and T%

Under the influence of hosts crops, position of vulva and length of testis differed within a small range. This marginal variation in the position of vulva and testis length in the adult *Hoplolaimus indicus* indicates that the reproductive organs of this species remain stable and do not shift their positions under hosts or crop rotations. Compared with other morphometric characters, these two parameters remained more or less stable. Similar observations on other nematode species were made by earlier workers (Bird and Mai, 1965, Evans and Fisher, 1970, Ray et al. 1985).