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OCCURRENCE OF LARGE NEMATODE POPULATIONS IN IRRIGATION CANALS OF SOUTH CENTRAL WASHINGTON

BY

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Studies carried out during the 1965 season at Prosser, Washington showed the presence of large numbers of nematodes in irrigation water. Water samples were collected with a depth adjustable sampling tube and nemas were extracted using modified screening and Baermann funnel techniques. Efficiency of the method was inversely proportional to the volume of water sampled. Distribution of nematodes within a canal was random as they did not concentrate in any portion of the canal and no tendency for them to settle out of flowing water was detected. Population densities in the Sunnyside and Roza Canals ranged from approximately 25 to over 200 nemas per gallon (3.775 l) of water, depending upon the date of sampling. Estimates from these data indicate that from 2 to 16 $\times$ 10^9 nematodes per day were carried past a given point. Plant parasitic nematodes generally accounted for 10-20% of those extracted from irrigation water with the highest concentration of these nemas occurring during mid-season in the Sunnyside Canal.

Of increasing concern in the newly irrigated lands of central Washington is the rapidity with which certain plant parasitic nematodes have spread, become established, and caused serious crop losses. Indigenous nematodes can account for only part of the plant parasitic fauna found. Undoubtedly certain nematodes, including the root knot nematodes *Meloidogyne hapla* Chitwood, *M. incognita* Chitwood, and *M. arenaria thamesi* Chitwood were introduced with various planting stocks. The alfalfa stem nematode *Ditylenchus dipsaci* (Kühn) was probably introduced with seed, whereas other nematodes such as the sugar beet nematode *Heterodera schachtii* Schmidt may have been introduced in soil adhering to plant roots, farm machinery, or the feet of livestock. However, the rapid and general distribution of all nematode pests cannot be explained solely by these means of dissemination. In a number of root knot nematode and alfalfa stem nematode infested fields of the Columbia Basin the only logical source of contamination appears to be irrigation water. Instances have been observed where fields less than 5 years removed from sagebrush desert have developed both severe and uniform infestations of root knot nematode. These fields had no history of vegetatively

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propagated planting stock or exchange of equipment from lands known to be nematode infested.

Numerous speculations about dissemination of nematode pests in flowing water have been expressed but only a few workers have presented data. Petherbridge & Jones (1944) and Thompson (1949) have discussed spread of sugar beet and potato root eelworms by floods. Subsoil drainage is considered by DuCharme (1955) as a factor in the spread of the burrowing nematode. Information on the occurrence of nematodes in irrigation water is extremely scarce. Godfrey (1923), investigating the alfalfa stem nematode disease in the Pacific Northwest, stated "The organisms may be carried for long distances by irrigation water. Waste water from infested fields carries the organisms by the millions. It may empty into a ditch that does duty lower down on the same farm or on an adjacent farm, or it may go back into a large lateral ditch or even a river, and thus be carried to another irrigation project miles away". However, information on sampling techniques and methods of estimating nematode populations in water was not given. In the late 1940's G. Thorne & E. C. Blodgett (pers. comm.) collected the potato rot nematode *Ditylenchus destructor* Thorne in waste water from irrigated fields in Idaho. There are no published references to this work and the number of nematodes collected is not known. Rostombekova (1957) reported the dissemination of nematode eggs in water in the Kaspi area of the Georgian U.S.S.R. Helminth egg contamination of the Lekhuri River was two eggs per liter, while 3.8 eggs per liter were collected from irrigation water. Cobb (1918) and Chang, Austin, Poston & Woodward (1959) and Chang, Woodward & Kabler (1960) have recovered several kinds of nematodes from municipal water supplies. These investigators developed certain kinds of equipment and techniques for collecting nematodes from small quantities of water.

The objective of this study was to develop techniques for estimating nematode populations carried by irrigation water and to gain some insight as to the potential importance of irrigation water as a disseminating agent for plant parasitic nematodes.

METHODS

Collection sites for water samples were selected on the Roza and Sunnnyside canals near the Irrigated Agriculture Research and Extension Center, Prosser, Washington. Both sites were at the lower end of their respective irrigation systems. The Sunnyside Canal, constructed in the early 1900's, serves the bottom lands of the Yakima Valley. The Roza Canal, on the other hand, was constructed in the late 1940's and serves a portion of the valley higher up on the slope leading to the Rattlesnake Range. Much of the waste water from fields in the Roza District is drained into the Sunnyside Canal. Thus the collection sites represented two distinctly different water sources with regard to their probabilities for nematode contamination.

Water samples were collected with a depth adjustable sampling tube (Fig. 1).

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L. R. FAULKNER & W. J. BOLANDER: *Nematode populations in irrigation canals.*

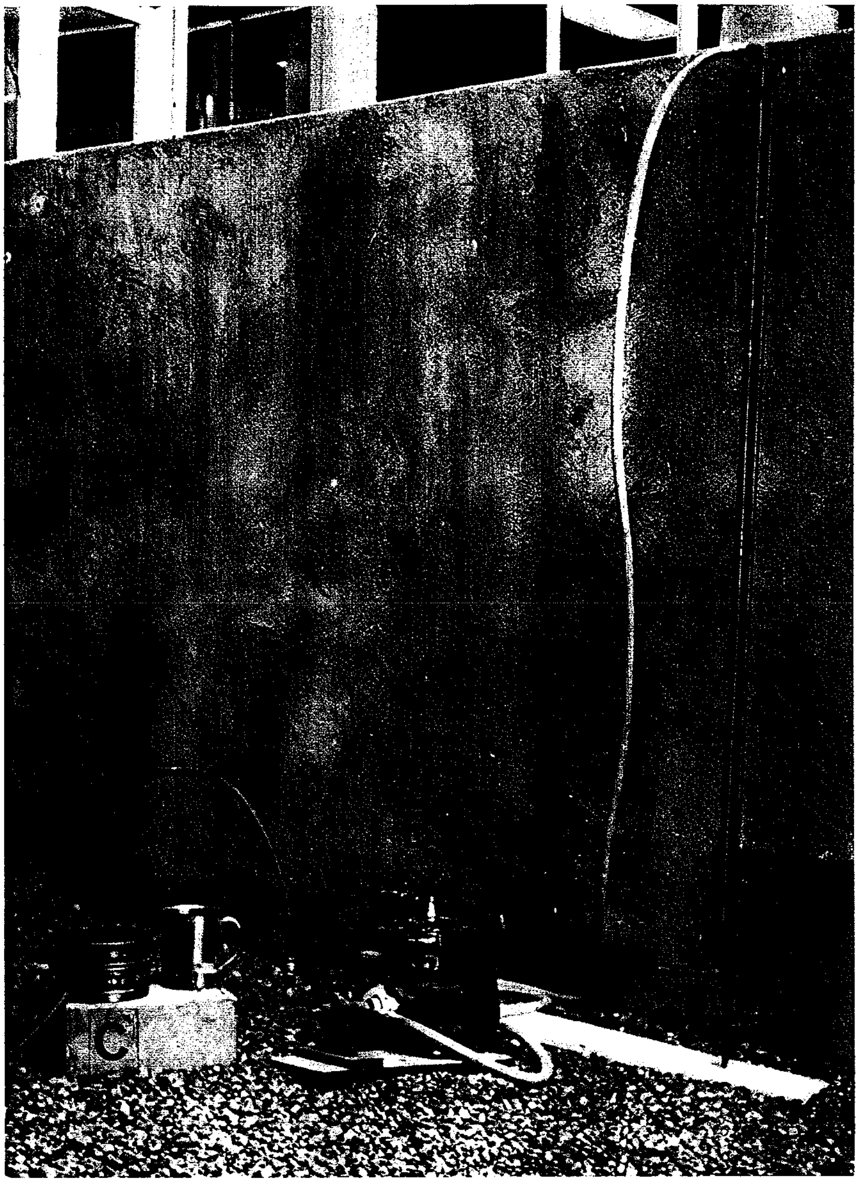

Fig. 1. Apparatus for sampling irrigation water. A) Depth adjustable sampling tube mounted on guide rod. Guide is fitted with a base plate to prevent apparatus from sinking into mud or sand and the fin serves to keep intake pointed into stream. B) 5 gpm pump driven by a gasoline engine. C) Stacked 32 and 400 mesh soil screens (pore size 0.340 and 0.025 mm respectively).

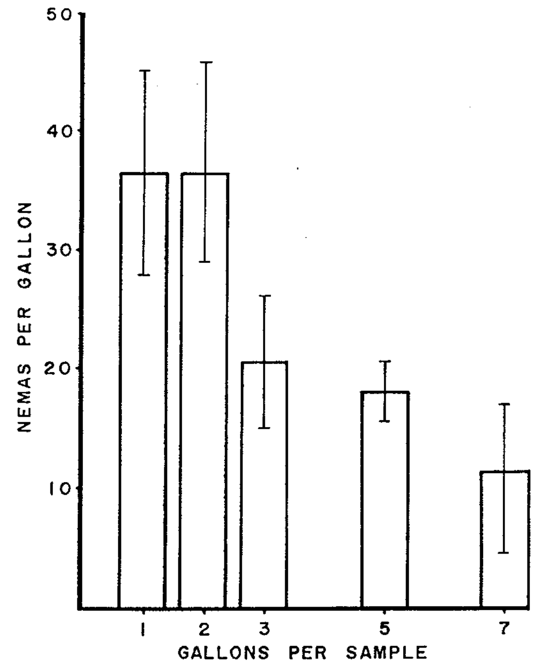

Fig. 2. Effect of sample volume on number of nematodes extracted per gallon (3.775 l) of water sampled.

The tube was attached by 5/8″ (1.56 cm) hose to a 5 gpm (18.93 lpm) neoprene impeller pump driven by a 4-cycle 2½ h.p. gasoline engine. Sample size was controlled by pumping timed volumes of water through stacked 32 and 400 mesh (pore size 0.340 and 0.025 mm respectively) soil sieves. The residues collected on the 400 mesh sieve were washed into 2 oz. (60 ml) glass jars and placed in a styrofoam cooler for transport to the laboratory.

Nematode extractions, using a modification of the Christie & Perry method (1951) were made by transferring the contents of the jars to 4 oz. (120 ml) paper cups and covering the cups with paper tissue (Kimwipe disposable wipers, type 900S) secured with a rubber band. The cups were then inverted over 3-partitioned plastic petri dishes (15 mm by 100 mm), containing sufficient water to cover the partitions, and incubated at room temperature for 24 hr to allow active nematodes to pass through the tissue. The contents of five dishes were combined in a 250 ml Erlenmeyer flask and the nematodes were allowed to settle over a 2-hr period. Nematode suspensions were prepared by siphoning off excess water and shaking the flasks.

Populations were estimated by pipetting 1 ml aliquots from these suspensions and placing them in a 1 ml capacity counting dish (Altman, 1965). Counts were made under a dissecting microscope using an 8-key laboratory counter. Records were kept on the total number of nemas and the parasitic genera present. The remaining

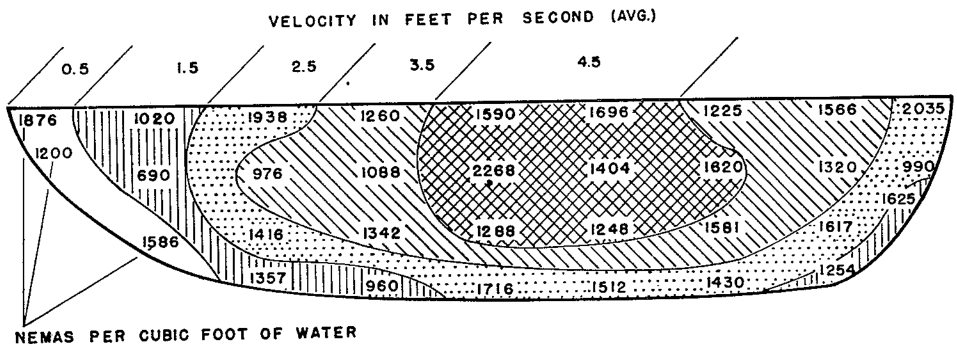

Fig. 3. Diagram of cross section of the Sunnyside Canal showing the number of nematodes collected per cubic foot (28.316 l) of water from each check point and the average velocity of water at these points.

nemas from each collection were combined, concentrated by centrifugation, relaxed with heat, fixed in TAF (Courtney, Polley & Miller, 1955) and stored in 15 ml glass vials for species identification at a later date. Data were collected on the optimum size of water samples, distribution of nematodes in the canal, and seasonal population densities in the irrigation water.

RESULTS

Optimum sample size, using the collection methods described above, was deter-

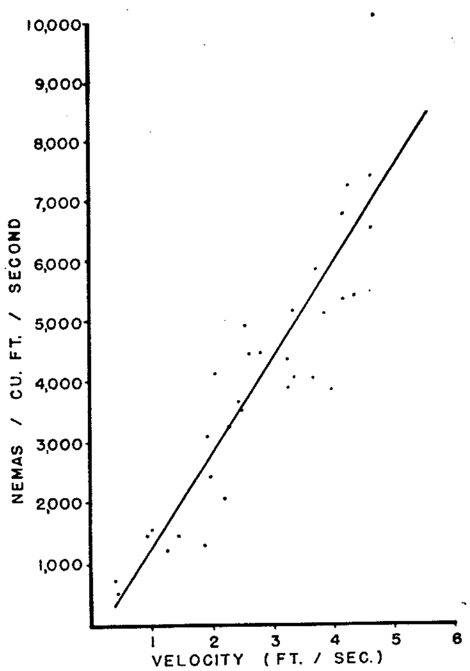

Fig. 4. Linear regression showing that the number of nemas carried past a given point varies directly with water velocity, indicating that nematodes were distributed at random in the canal ($r = 0.89^{**}$).

mined by extracting nematodes from 1, 2, 3, 5 and 7 gal. (3.775, 7.550, 11,325, 18.926 and 26.476 l) water samples. Five samples representing each volume were combined to make each reading and the procedure was repeated five times. Fig. 2 is a compilation of these data, showing the average number of nematodes extracted per gallon (3.775 l) of water among the various sample sizes and the variation within samples. Number of nematodes extracted per gallon water varied inversely with the sample size. However, variation within a sample size was least when 5-gallon samples were taken. The 2-gallon sample was selected for use in all additional studies since it gave a high per gallon yield of nematodes and large enough numbers to permit relatively accurate population estimates.

To determine distribution of nematodes within a canal, a foot bridge was placed across the Sunnyside Canal at a point below a 155 yard (151.77 m) straight run. Samples were taken at two-foot intervals from bank to bank and from surface to bottom at one-foot intervals. Water velocities at these points were measured with a standard Price current meter. Fig. 3 is a diagrammatic cross section of the canal and shows the average number of nematodes collected per cubic foot of water (28.316 l) at each check point. Also shown are 5 arbitrary zones having average water velocities ranging from 0.5 to 4.5 feet (15.24 to 1,371.60 cm) per second. Fig. 4 is a linear regression made from these data, the y axis representing the number of nematodes per cubic foot of water per second, and the x axis representing the velocity of water in second feet. The numbers of nemas passing a given point varied directly with water velocity. These data show that nematode population densities were at complete random in the canal and indicate there is little tendency for nematodes to settle out in flowing water.

Seasonal fluctuations in nematode populations were followed during the 1965 season in the Sunnyside and Roza canals. Nematode extractions were made at weekly intervals from 50 two-gallon (7.550 l) samples taken from each canal over a 26-week period, April 5 through September 27. Data were recorded on the total population of nematodes and the numbers of plant parasites present.

Population densities in the canals ranged from approximately 20 to over 200 nematodes per gallon of water (Fig. 5A). Three periods were observed during the season where population densities reached distinct peaks, these occurring in mid-May, early July, and late August.

Plant parasitic nematodes accounted for approximately 10 to 20 percent of the total population present. Species of *Ditylenchus, Paratylenchus, Pratylenchus, Tylenchorhynchus*, *Heterodera*, *Meloidogyne*, *Trichodorus*, and *Hemicycliophora* were among the plant parasites observed. The Roza Canal contained higher populations of plant parasitic nematodes during the first 10-week period. However, populations of plant parasites from the Sunnyside Canal exceeded those from the Roza Canal for the remainder of the season (Fig. 5B). Highest population densities of plant parasitic nematodes occurred in the Sunnyside Canal during the month of July when peak populations exceeded 20 plant parasites per gallon of water.

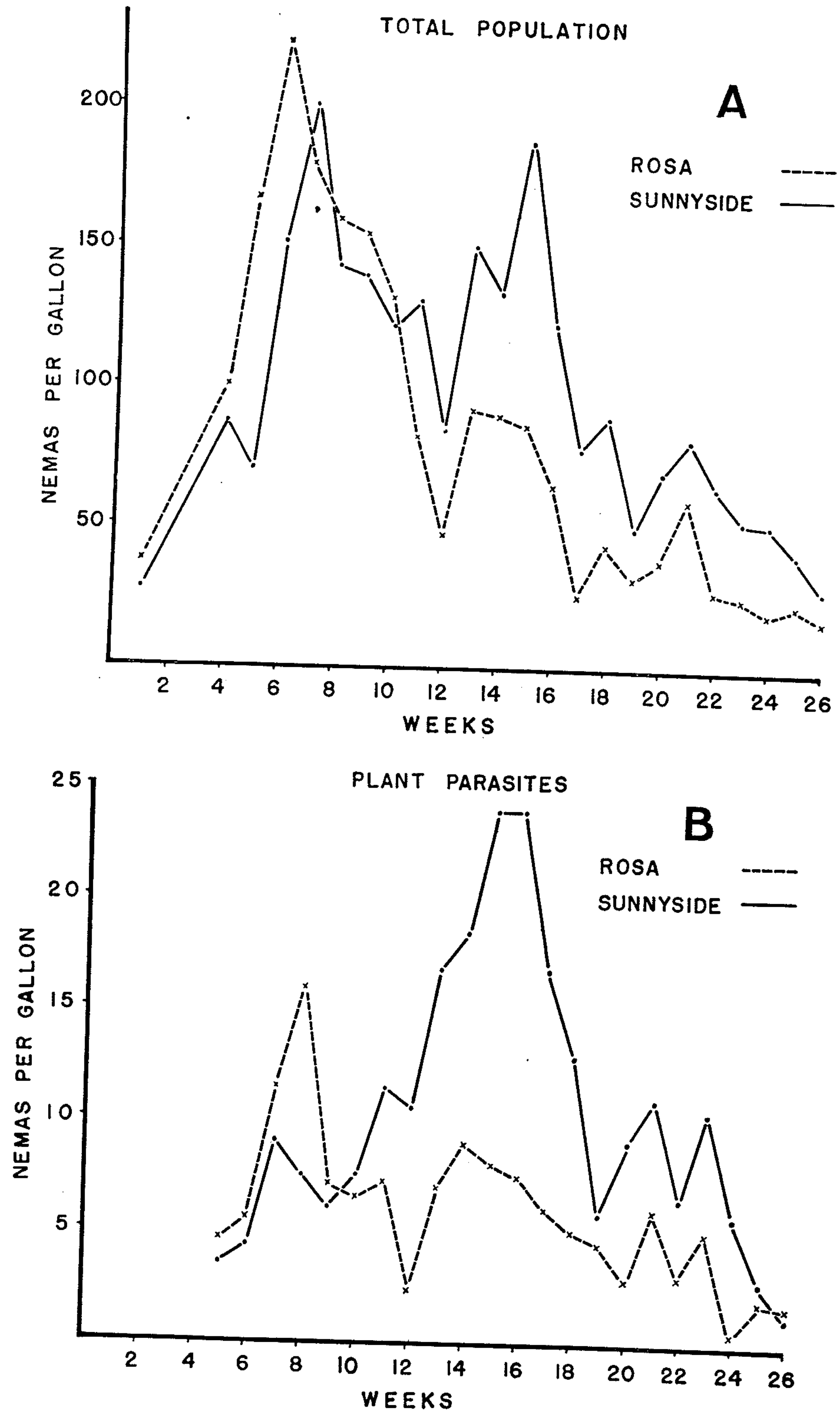

Fig. 5. Average number of nematodes extracted at weekly intervals per gallon (3.755 l) of water from the Sunnyside and Roza canals near Prosser, Washington. A) Total population. B) Plant parasites.

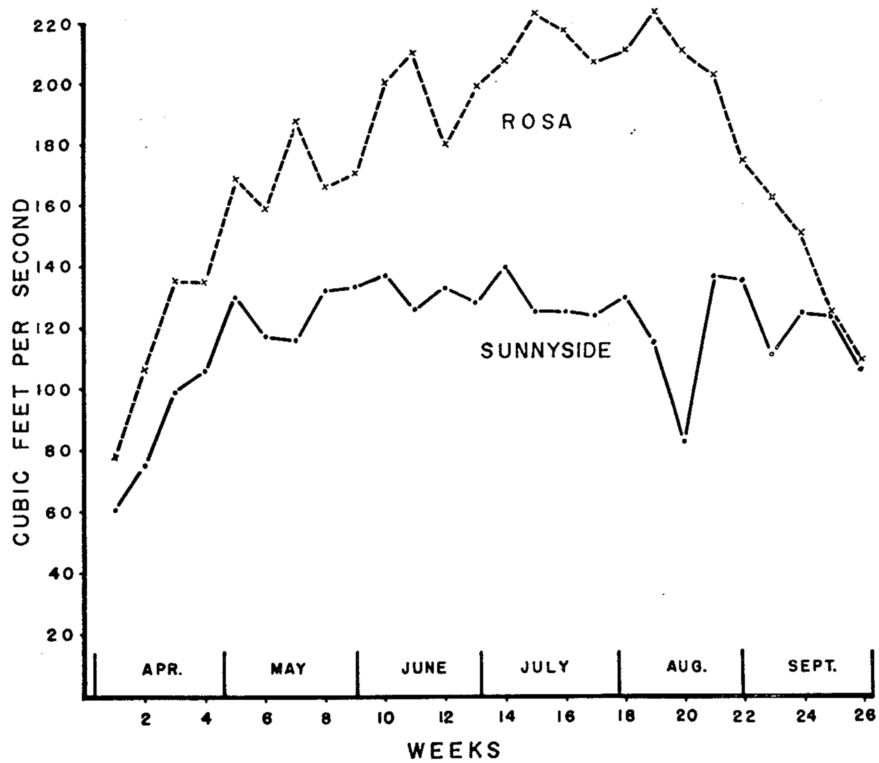

Fig. 6. Flow data for sample points on the Sunnyside and Roza canals as obtained from the Sunnyside Valley and Roza Irrigation District Headquarters, Sunnyside, Washington.

Estimates were made of the total numbers of nematodes carried by the Roza and Sunnyside canals during the season. Flow data obtained from the Sunnyside valley Irrigation District headquarters and the Roza Irrigation District headquarters, both located in Sunnyside, Washington, are shown in Fig. 6. The flow data were used to calculate the number of nematodes per day carried past a given point in each canal (Fig. 7A). The three peak population periods were again observed. The nematode content of the Roza Canal was highest during the month of May, then declined throughout the remainder of the season. The Sunnyside Canal, on the other hand, carried peak populations in May and again in July before declining. Plant parasites in the Roza Canal followed the same general trend as was indicated for the total population (Fig. 7B). However, the population of plant parasites in the Sunnyside Canal did not reach a peak until mid-season. These data would indicate that dumping waste water from the Roza Irrigation District into the Sunnyside Canal increases the number of plant parasitic nematodes carried by the Sunnyside Canal. It is noteworthy that the Sunnyside Canal carried approximately as many nematodes throughout the season as did the Roza Canal, even though its flow volume averaged only about 60 per cent of that for the Roza.

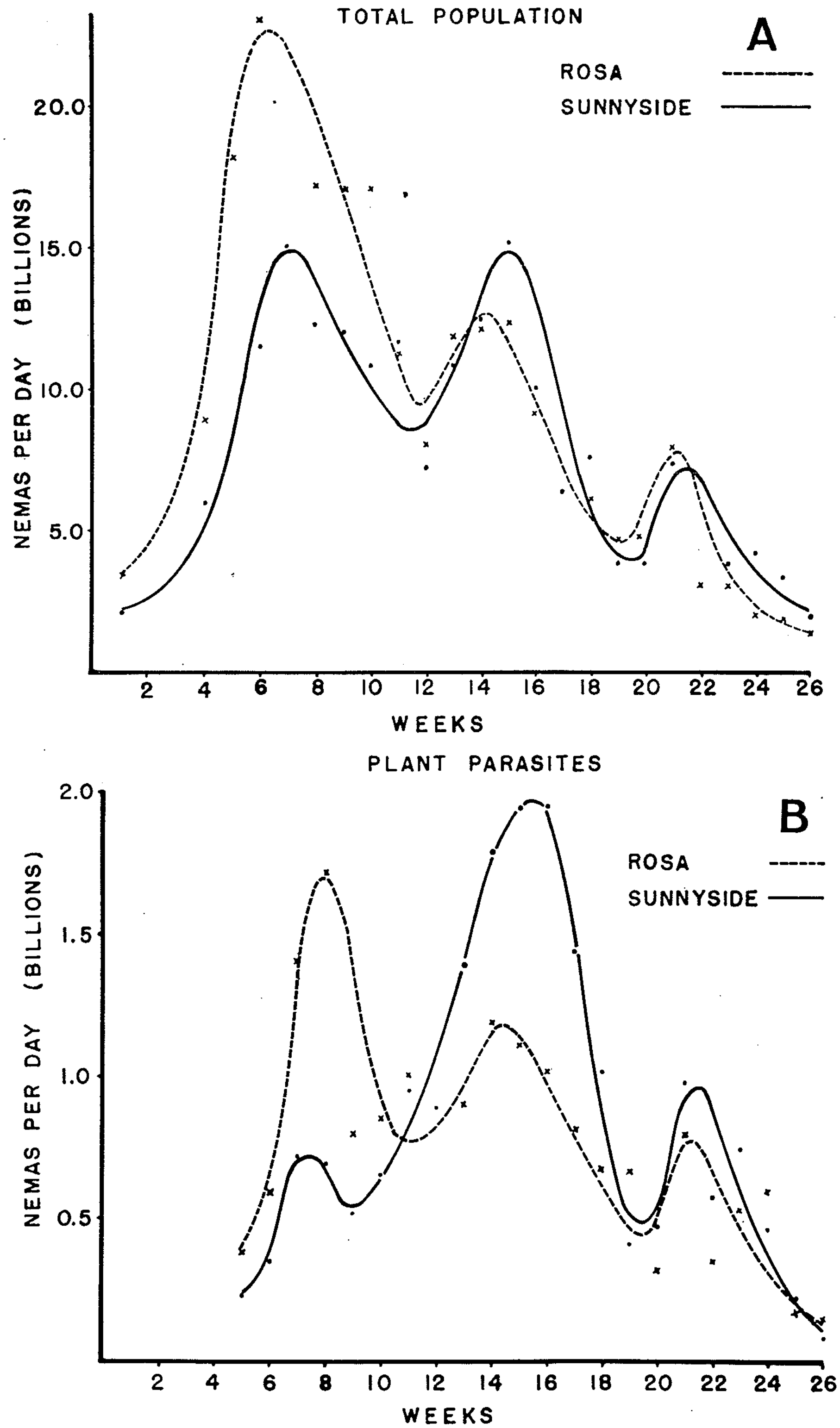

Fig. 7. Estimated population in nematodes per day passing the sample points over a 26-week period. A) Total population. B) Plant parasitic nematodes.

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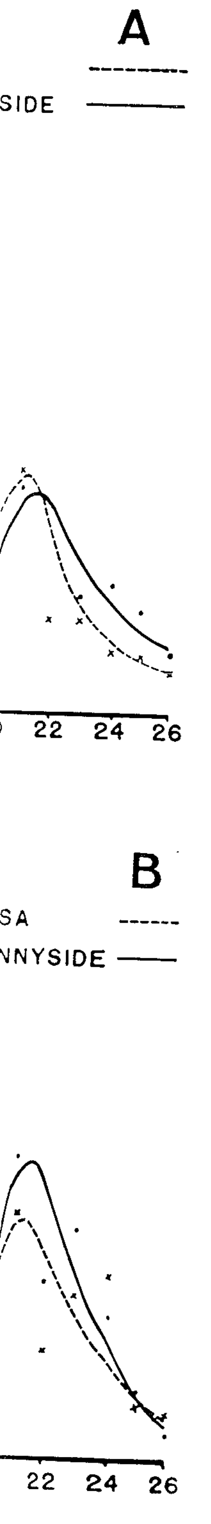

ver a 26-week period.

DISCUSSION

These data confirm that large numbers of nematodes, including plant parasites, are transported in irrigation water. No attempt has been made to ascertain the economic importance of nematodes distributed by water. However, there is little doubt that irrigation water could be a significant source of nematode infestations. The data given in this paper indicate that each time an acre (0.4 ha) of land in the Lower Yakima Valley is irrigated, it may receive from approximately 4 million to over 10 million plant parasitic nematodes.

The data presented on the nematode content of the two canals studied are conservative estimates since the procedures used would give no indication of the number of eggs or numbers of molting or otherwise inactive worms present. Also, since the number of nematodes extracted per gallon of water varied inversely with the volume of water per sample, improved extraction procedures are needed before accurate estimations of the nematode load of irrigation water can be made.

Although data were compiled indicating that nematodes do not tend to settle out in flowing water, these data are probably valid only where a relatively narrow range in water velocities is encountered. Data were not collected from locations in the canal along the bottom and sides, where water velocity is essentially nil. The effects of decreasing flow rates, such as might occur in settling basins, ponds and reservoirs, also were not studied.

Additional work is needed before the full significance of irrigation water as a disseminating agent for plant parasitic nematodes (or other plant pathogens) can be evaluated. Modes of nematode acquisition, longevity of plant parasites in water, and rates of introduction into non-infested land also need investigation.

ZUSAMMENFASSUNG

Das Vorkommen großer Nematodenpopulationen in Bewässerungskanälen in Süd-Mittelwashington

Im Laufe des Jahres 1965 in Prosser, Washington, durchgeführte Untersuchungen ergaben die Anwesenheit zahlreicher Nematoden im Berieselungswasser. Die Wasserproben wurden mit einer tiefenverstellbaren Röhre entnommen und die Nematoden mit einer veränderten Siebmethode und dem Baermanntrichterverfahren abgetrennt. Der Wirkungsgrad der Methode war umgekehrt proportional zum Probenvolumen. Die Verteilung der Nematoden in einem Kanal erwies sich als zufällig. Die Tiere sammelten sich an keiner Stelle und zeigten auch keine Neigung zum Absetzen aus dem fließenden Wasser. Die Populationsdichte schwankte je nach dem Zeitpunkt der Probenahme im Sunnyside-Kanal und im Rosa-Kanal zwischen rund 25 und mehr als 200 Nematoden je Gallone (3,775 l) Wasser. Nach diesen Werten passieren täglich 2 bis 16 $\times$ 10^9 Nematoden eine gegebene Stelle. Pflanzenparasitäre Nematoden machten etwa 10-20 % der gewonnenen Älchen aus, wobei der größte Anteil im Hochsommer im Sunnyside-Kanal gefunden wurde.

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