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Division of Nematology, University of California
Davis, California 95616, U.S.A.

BACKGROUND ATMOSPHERIC BURDEN OF NEMATODES IN CALIFORNIA'S SACRAMENTO VALLEY

by
D. R. VIGLIERCHIO and R. V. SCHMITT

Arid and semi-arid regions of the world, southwestern United States, North Africa and the Mediterranean basin, Asia, Australia, and elsewhere periodically suffer dry wind storms of high intensity that lift and carry soil particles long distances. It has long been suspected that aerial transport of nematodes might be a factor in their distribution (Filipjev and Schuurmans Stekhoven, 1941). Although nonviable cysts of the golden nematode of potatoes were collected from a trap suspended 150 cm above a heavily infested field, viable cysts were found in wind-blown soil collected from the surface of snowdrifts some 300 meters from an infested field (Chitwood, 1951). Subsequently White, 1953, suggested that strong winds over infested potato fields were capable of transporting potato root eelworm to other fields. In a report from West Texas, a region with frequent dust storms, sediment from dust traps were found to contain 28 genera of nematodes, half of which were plant-parasitic forms (Warn and Cox, 1951). In a review concerned with world dissemination of the cereal cyst nematode it was suggested that wind transport was the primary mode of dispersion of the nematode in the wheat fields of Australia (Orr and Newton, 1971; Meagher, 1977). In heavy dust storms several centimetres of topsoil (and its associated burden of nematodes) may be transported considerable distances. However, the carrying potential of wind under milder conditions is poorly understood. This study was intended to assess the dissemination of soil and nematodes under the wind conditions of a normal summer in the Sacramento Valley of California.

To monitor normal atmospheric particulate matter (background) seven stations were set up within commuting distance of the University of California, Davis campus. Stations one and two were placed at the TV tower in Walnut Grove, CA; one at five m, the other at 500 m. Stations three and four were set up on the Davis campus, one at a weather station (5 m) and one on the roof of the building that houses the Division of Nematology laboratories (40 m). The fifth and sixth stations were 80 Km north of Davis; one was placed on the Grey Lodge National Wildlife Refuge (5 m) and the other at the microwave relay station atop Sutter Buttes (650 m). The seventh station was placed at the Stateline Fire Lookout Station, North Lake Tahoe (2160 m), in the Sierra Nevada Mountains. Each station had three sampling devices, one to collect dry air samples, a second that served as a water trap to humidify and maintain moist any trapped particles and the third was a standard rain gauge. Ambient air was pulled through the dry or water trap collectors by means of a vacuum pump.

The dry air collector consisted of four probes, each fitted with a 47 mm diameter polypropylene filter, average pore size 10 μm. One probe was fitted with a filter dried to constant weight. At collection time the weight of particulate matter collected on this filter was determined. The filter was also subsequently submitted to trace element analysis by alpha particle X-ray excitation. The filters in the other three probes were moistened for three days before being scrubbed lightly with a brush and then rinsed. The particulate matter was collected and centrifuged and the pellet examined for nematodes.

The water-trap collector was allowed to sediment for 48 h after which the bulk of the supernatant was decanted. The remaining suspension was centrifuged and the pellet examined for nematodes. The rain gauge samples were treated in a manner similar to the water-trap sample. Samples were collected on a weekly basis beginning two weeks after the last spring rain and continuing through the summer and fall until the normal fall rainy season began.

Soil and dust samples were collected at random locations throughout the Sacramento valley. At each location a soil sample was taken from the upper 2 to 3 cm of soil, a dust sample was taken from a tractor or farm implement at a height of at least 1.5 m from the soil and when possible the tractor air cleaner was emptied and collected. A 50 ml sample of each was moistened for a week then wet-screened. The sieve collections were placed on a Baermann funnel for 2 days and the live nematodes collected at the funnel tip were fixed in 2½% formalin and identified to genus.

Results and Discussion

No nematodes were collected from either the dry or wet traps at any station throughout the summer. The vacuum created by the pump pulling air through the dry filters increased by the end of the week to a level determined by the amount of particulate matter occluding the pores of the filter. It was estimated that on an average of 150 m^3 of air were pulled through the filters per week. The water trap collector caused less back pressure so that approximately 225 m^3 were processed per week. The detection limits of the apparatus and methodology was determined by assessing the efficiency of the recovery of known numbers of nematodes added directly to the traps. Using *Macroposthonia xenoplax*, *Meloidogyne hapla*, *Pratylenchus vulnus*, and *Panagrellus silusiae* one of five nematodes could be collected and counted reproducibly from the water trap device. The same results were obtained from the dry air filters for all nematodes except *Meloidogyne hapla* for which over 10 were necessary before detection was possible. In the absence of dust storms it appeared that the nematode concentration in the atmosphere was less than 1 nematode per approximately 150 m^3 as determined by the dry filter method and less than 1 nematode in approximately 200 m^3 by the water trap method. No nematodes were found in the rainfall collections, but it was not possible to determine what volume of air was scrubbed by the rain collected. The California central valley is usually rainless from late spring to early fall; unfortunately during this particular summer, several light rains, occurring irregularly, tended to precipitate airborne particles. The quantity of particulate matter in atmospheric suspension varied substantially throughout the summer season at all stations except perhaps the mountain station at Stateline at which the levels were generally somewhat lower (Table I). The composition of the particulate matter in atmospheric suspension was not uniform over the region examined. Trace element analysis indicated quantitative and qualitative differences in the particle samples collected from the various stations. As similar but less pronounc-

Table I - *Particulate Matter Suspended in Atmosphere*
($\mu g/m^3$ averaged over the week)

($\mu g/m^3$ averaged over the week)

Week	Weather Station	Storer	Tower Top	Tower Base	Gray Lodge	Sutter Buttes	Stateline
5/26	—	46	34	30	54	102	—
6/2	42	38	24	12	42	62	—
6/9	100	104	42	26	64	76	32
6/16	54 *	50 *	24	46	70	70	32
6/23	64	34	24	16	74	78	16
6/30	112	88	20	52	62	54	28
7/7	34 *	24 *	22	10	36	28	12
7/14	28	40	20	22	14	12	14
7/21	54	42	12	42	58	74	20
7/28	92	52	38	104	—	68	30
8/4	— *	18 *	22	24	28	26	24
8/11	30	28	8	38	44	18	16
8/18	20	20	20	22	60	30	4
8/25	16	16	8	66	48	22	42
9/1	10	26	10	12	50	32	24
9/8	46	72	4	12	46	24	24
9/15	96	—	20	30	48	36	74
9/22	122	118	26	12	—	26	4
9/29	38	104	8	20	78	20	16
10/6	42	8	2	48	24	84	12
10/13	38	98	12	16	70	34	32
10/20	24	24	24	18	60	56	26
10/27	52 *	6 *	20	4	8	12	4

* Rainfall recorded at Davis

ed differences occurred at some stations over the summer season it appeared that the atmospheric particle composition may have been a reflection not only of the general soil types in the area of the stations but also of particular soil types and the preparative agricultural activity associated with them for different crops.

Having established that the residual atmospheric concentration of nematodes was very low it was of interest to determine whether agricultural activity, particularly in the form of agricultural implements traversing a dry field, would raise live nematodes above the soil surface sufficiently to expose them to transport by gentle wind

Table II - *Live Nematodes Recovered from Implement Dust Deposit and Dry Soil*
(Nematode Genera in Percent of Nematodes Found)

Sample		*Aphelenchoides*	*Aphelenchus*	*Tylenchus*	*Ditylenchus*	*Rhabditida*	*Dorylaimida*	*Tylenchorhynchus*	*Pratylenchus*	*Helicotylenchus*	*Scutellonema*	*Percent Soil moisture*
N° 1	Soil	0	8	0	0	54	15	15	8	0	0	
	Dust	5	36	0	0	55	4	0	0	0	0	
N° 2	Soil	27	11	2	0	25	6	30	0	0	0	
	Dust	19	21	10	0	50	0	0	0	0	0	
N° 3	Soil	9	22	30	0	35	2	2	0	0	0	
	Dust	27	36	9	0	27	0	0	0	0	0	
N° 4	Soil	21	8	38	8	15	0	0	8	4	0	
	Dust	25	25	13	0	38	0	0	0	0	0	
	Air Cleaner	27	20	0	0	53	0	0	0	0	0	
N° 5	Soil	0	65	8	8	16	0	0	0	0	0	
	Dust	0	100	0	0	0	0	0	0	0	0	
N° 6	Soil	50	0	0	4	45	0	0	0	0	0	13
	Dust	41	11	3	0	41	4	0	0	0	0	7
	Air Cleaner	38	19	6	0	38	0	0	0	0	0	2
N° 7	Soil	55	0	1	4	31	8	0	0	0	1	
	Dust	68	0	0	0	32	0	0	0	0	0	
	Air Cleaner	63	0	0	0	37	0	0	0	0	0	
N° 8	Soil	0	14	0	0	24	62	0	0	0	0	4
	Dust (Lost)											2
	Air Cleaner	0	50	0	0	50	0	0	0	0	0	2
N° 9	Soil	8	41	34	0	9	8	0	0	0	0	
	Dust	3	28	56	0	11	3	0	0	0	0	
	Air Cleaner	0	36	55	0	9	0	0	0	0	0	
N° 10	Soil	5	12	5	7	23	12	22	14	0	0	
	Dust	9	8	6	6	30	6	4	30	0	0	
	Air Cleaner	22	0	33	0	44	0	0	0	0	0	0

currents. The live nematodes collected from each sample were separated, fixed and identified to genera (Table II). Qualitatively the number of genera appearing in each sample diminished from soil to dust to air cleaner dust. No attempts were made at selection of fields, for heavy infestations or extreme dryness, the kind of farm implement traversing a field or, in the case of air cleaners, the kind of tractor used. In some vehicles the air cleaner was positioned so as to be subject to greater motor heat which could account in part for the variability in recovery of live nematodes. In an incidental observation one of us (RVS) recovered live *Xiphinema index* from implement dust.

There seems to be no question but that a large variety of nematodes can survive field drying, be lifted into air suspension by various forces and transported by wind currents. Yet to be resolved are the nature of wind forces which can lift nematodes from the soil into the atmosphere and the carrying capacity of wind currents.

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SUMMARY

The residual airborne burden level of nematodes throughout a mild summer in the central Sacramento valley subject to the usual summer breezes was less than 1/150-200 m^3. Dust raised by farm implements was found to contain viable plant parasitic nematodes.

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