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Ecology and pathogenicity of the Hoplolaimidae (Nemata) from the sahelian zone of West Africa. 1. Field studies on *Scutellonema cavenessi* Sher, 1964

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Summary – Nematode population densities increased during the rainy season, root population densities being always below 25 % of the total population, and decreased during the dry season during which nematodes enter anhydrobiosis; they varied according to the geographical location of sampling, rainfall and soil moisture (these three parameters being linked), and to host plant. As the year proceeds, nematodes are mainly located in the upper layers of the soil (0-20 cm deep). Multiplication rates were low, generally less than 25, survival rates being higher, from 10 to 65 %; these rates varied with the year of observation and with the host plant. The record of significant and positive relationships between initial population densities of the nematode and peanut yield did not confirm previous data on the pathogenicity of the nematode to peanut.

Résumé – *Écologie et nocuité des Hoplolaimidae (Nemata) de la zone sahélienne d'Afrique de l'Ouest. 1. Études au champ sur* Scutellonema cavenessi *Sher, 1964* – Les taux de population du nématode évoluent au rythme des saisons, avec un accroissement pendant la saison des pluies suivi d'une réduction lors de la saison sèche durant laquelle le nématode entre en anhydrobiose; les taux de population endoracinaire restent toujours inférieurs à 25 % de la population totale. Les taux de population varient avec la localisation géographique, la pluviosité et l'humidité des sols (ces trois facteurs étant liés), l'hôte végétal. Durant toute l'année, les nématodes restent majoritairement localisés dans les couches supérieures du sol (0-20 cm). Les taux de multiplication sont faibles, généralement inférieurs à 25 alors que les taux de survie sont plus élevés, variant de 10 à 65 %; ces taux varient suivant l'année d'observation et l'hôte végétal. La mise en évidence de corrélations positives significatives entre taux de population initiale du nématode et rendements de l'arachide ne confirme pas les données antérieures sur la nocuité de cette espèce vis-à-vis de l'arachide.

Key-words : *Scutellonema cavenessi,* nematode, West Africa, population densities, population dynamics, multiplication rates, survival rates, vertical distribution, cultural practices, peanut yield.

Surveys on phytoparasitic nematodes in semi-arid regions of West Africa (Senegal, Mali, Burkina Faso, Niger) have shown that nematodes belonging to the family Hoplolaimidae Filip'ev, 1934 are always frequent and abundant in these soils : up to now, nine species have been identified in the rhizosphere of pluvial crops and natural vegetation *(Aorolaimus macbethi, Aphasmatylenchus straturatus, Aphasmatylenchus variabilis, Helicotylenchus dihystera, Hoplolaimus pararobustus, Scutellonema cavenessi, Scutellonema clathricaudatum, Rotylenchulus borealis, Senegalonema sorghi)* and a tenth associated with vegetable crops under irrigation *(Rotylenchulus reniformis)* (Sharma *et al.*, 1988, 1990; Sharma, 1990; Baujard & Martiny, 1994, 1995 *a, b*). Three of them are considered as major parasites of peanut in West Africa : *A. straturatus* in Burkina Faso (Germani & Luc, 1982), *S. cavenessi* in Sénégal (Germani *et al.*, 1985) and *S. clathricaudatum* in Niger (Sharma *et al.*, 1992).

Studies were undertaken in order to determine the ecology of these species (except *R. borealis* which cannot be reared in the laboratory) and their pathogenicity to pluvial crops of this region. This work deals with field observations and studies on *S. cavenessi.*

S. cavenessi is a common species in Africa : Mauritania (Baujard & Martiny, 1995 *b*), Sénégal (Germani *et al.*, 1985), Mali (Baujard & Martiny, 1994), Nigeria (Sher, 1964), Congo (Elmiligy, 1970), Cameroun (Sakwe & Geraert, 1991), South Africa (Van Den Berg & Heyns, 1973). *S. cavenessi* is present in all the sudano-sahelian area of Senegal (Germani *et al.*, 1985) and in the south-west of Mali. To the east and the south of this area, *S. cavenessi* disappears, being replaced by

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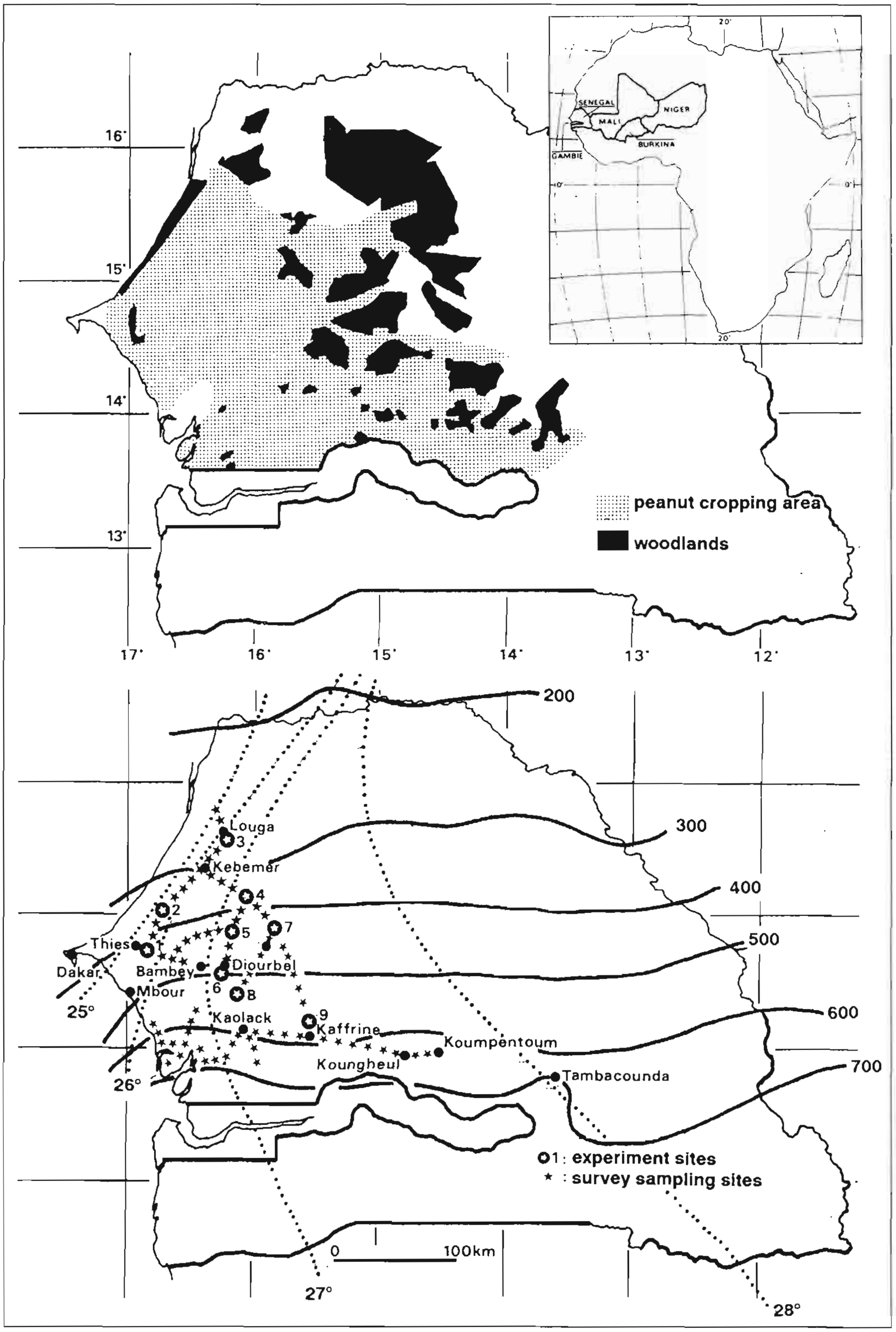

Fig. 1. *Location and characteristics of the peanut cropping area of Senegal* (Dotted lines : annual mean isotherms; continuous lines : annual mean isohyets).

S. clathricaudatum in Mali (Baujard & Martiny, 1994); *S. clathricaudatum* is also present in Niger and Burkina Faso (Sharma *et al.*, 1988, 1990; Sharma, 1990), Sierra Leone (Vovlas *et al.*, 1991), Ivory Coast (Malcevschi, 1978), Ghana (from slides of the Collection Nationale des Nématodes, Muséum National d'Histoire Naturelle, Paris), Benin (Sharma, 1990) and Nigeria (Sher, 1964).

The peanut cropping area of Senegal occupies an area of 600 000 ha characterized by a short rainy season with low rainfall amount, high temperatures, and sandy soils. The nematode *S. cavenessi* is the most abundant and widespread species considered as a major parasite of peanut (*Arachis hypogea* L.) and other pluvial crops in Senegal (Germani, 1981 *b;* Germani *et al.*, 1985). *S. cavenessi* is able to enter anhydrobiosis during the dry season (Demeure, 1980); it is a semi-endoparasite (Demeure *et al.*, 1980) characterized by an obligatory cessation of the reproductive activity throughout the dry season (Germani, 1981 *a*).

Material and methods

Nematode extraction

Nematodes were extracted from soil (250 cm^3) by elutriation (Seinhorst, 1962) and from roots in a mist chamber (Seinhorst, 1950). Elutriates were placed on Baermann trays and the nematodes were counted after 7 and 14 days.

Population dynamics and vertical distribution

Studies were conducted in a field previously cropped with millet at Nebe 5 km south of Diourbel (experiment site 6 on Fig. 1).

Population dynamics were studied in field plots (6 × 6 m) separated by 3 m wide, non-cropped, and weekly weeded alleys. The experiment consisted of 42 plots, seven treatments (Table 1) each with six replications (monocultures of peanut [*Arachis hypogea* L. cv. 55 437], millet [*Pennisetum typhoides* Rich. cv. Souna III], sorghum [*Sorghum vulgare* L. cv. 51 69] and cowpea [*Vigna unguiculata* (L.) Walp. cv. N58 57], biannual peanut-millet rotation without nematicical treatment, biannual peanut-millet rotation with a nematicidal treatment and permanent fallow) were arranged in a completely randomized pattern. Sorghum exhibited very poor growth in 1984 and did not develop during the following seasons. Nematicidal treatment was achieved by injection of metam sodium (31.25 kg/ha a. i.) at 15 cm depth at the beginning of the experiment. All the plots except those constituting the fallow treatment were weeded weekly during the rainy season. Soil samples were taken monthly during the dry season and biweekly during the rainy season, from April 1984 to August 1988. Three 250 cm^3 soil samples per plot were thoroughly mixed and one 250 cm^3 subsample was extracted for nematode counting.

Multiplication rates during the year were calculated from countings registered at the end of each dry season (initial population) and at the beginning of each following dry season (final population). Survival rates during the dry season were calculated from data taken at the beginning of the dry season (initial population) and at the end of the same dry season (final population).

Two studies on the vertical distribution of the nematode populations were conducted during the dry season (December 1984-January 1985), and the rainy season (September-October 1987). Two 2 m^3 holes were dug in the alleys along each plot. Two samples were taken in each hole along the side adjacent to the plot at 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 cm deep during the dry season and at 5, 10, 15, 20, 30, 40, 50, 60, 70, 80 cm deep during the rainy season. The four samples collected for each depth were thoroughly mixed and one 250 cm^3 subsample was extracted for nematode counting.

Table 1. *Characteristics of the treatments in the field experiment conducted at Nebe.*

Treatment			Plant cropped during the rainy seasons			
Code	Cultural practice	Nematicide application	1984	1985	1986	1987
A	monoculture	no	peanut	peanut	peanut	peanut
B	rotation	no	peanut	millet	peanut	millet
C	rotation	yes	peanut	millet	peanut	millet
D	monoculture	no	millet	millet	millet	millet
E	monoculture	no	sorghum	sorghum	sorghum	sorghum
F	monoculture	no	cowpea	cowpea	cowpea	cowpea

Field observations on abundance, relations between initial and final populations and between initial population and peanut yield

During surveys conducted on peanut crops in the whole of the peanut growing area of Senegal, relations between *i)* nematode density (final population on control plots on nematicide trials), rainfall, and geographical location, *ii)* nematode density (initial population on control plots) and peanut pod yields, were calculated from data collected from all the experiment sites (sites 1-9 on Fig. 1).

Relations between nematode density (initial population), multiplication rate and peanut (pods and straws) yield were studied on the experiment site 5 (Fig. 1). Two years after the nematicide trial, the field was cropped with peanut cv. 55 437; 105 microplots (4 m^2) were sampled two months before the first rainfall for determination of initial populations levels. Peanut was hand-sown at 0.45×0.15 m at two seeds per seed-hole and thinned 15 days later; it was harvested three months after sowing; final populations were estimated 120 days after sowing.

Results

Population dynamics

Soil populations increased for all cultural practices during the rainy season and during 0-30 days after the last rainfall; this increase was sometimes stopped following drought periods; root populations remained low, never reaching more than 25 % of the total population; during the dry season, population levels decreased first abruptly for 1 or 2 months and then regularly up to the first rainfall of the next rainy season (Fig. 2). The cultural practice affected the maximal population density : 15 000-40 000 nematodes per dm^3 of soil under millet and cowpea, 10 000-15 000 under fallow and 5000 under peanut; this effect was well marked on the peanut-millet rotation where population densities were higher under millet than under peanut. Injection of nematicide at the beginning of the experiment induced a strong reduction of the nematode population density; one year after, high multiplication allowed the reconstitution of the population at the same densities as those observed on the plot under rotation without nematicide injection (Fig. 2 B, C). Studies of the population dynamics over 4 years showed a stability of the nematode population : nematode densities observed at the beginning of each rainy season remained relatively constant according to the cultural practices (Fig. 2).

Multiplication rates during the rainy seasons varied from 1 to 12, according to the cultural practices and the time of observation; values registered for sorghum in 1987 can not be considered owing to the poor growth of the crop. Low and high values registered respectively in 1984 and 1985 for the peanut-millet rotation with nematice injection were correlated with *i)* the nematode mortality following the use of nematicide and *ii)* the rapid reconstitution of the population under millet suggesting that high multiplication rates might be related to low initial population levels. Alternate years with low and high multiplication rates was registered for all cultural practices (Fig. 3).

Survival rates during the dry season varied from 10 to 65 % according to the year of observation; no effect of the cultural practice was registered; high value on peanut-millet rotation plots during the first dry season of the experiment was probably due to very low initial population density following nematicide application (Fig. 3). A decrease of the survival rates was registered from 1984 to 1988 for all the cultural practices except on the fallow plots where they remained constant.

Vertical distribution

A total of 80-90 % of the nematodes were located in the upper layers of the soil (0-20 cm) during both the rainy and dry seasons; populations decreased to very low levels below 30 cm deep for all cultural practices. The distribution pattern was not affected by the cultural practices except for fallow where high nematode densities were registered in the 0-5 cm deep layer, probably related to the absence of hand weeding during the rainy and dry seasons (Fig. 4).

Field observations on abundance, relations between initial and final populations, and between initial population and peanut yield

Nematode densities increased from the north to the south of the peanut cropping area of Senegal, an increase apparently correlated to the rainfall (Fig. 5 A, B) which also varies from the north to the south of the area (Fig. 1).

Analysis of the relations between initial and final nematode populations under the peanut crop showed that the nematode multiplication rates decreased as the initial population level increased, up to a density of 1000-2000 nematodes per dm^3 of soil; above these densities, decrease of the nematode population occurred (Duncan, pers. comm. Fig. 5 C). For an initial population level of 0-1000 nematodes per dm^3 of soil, multiplication rates were mostly low, varying from 1 to 15 (Fig. 5 D).

Analysis of the relations between initial nematode population levels and peanut pod yields showed a significant ($P < 1$ %) correlation with the same trends either in the whole of the peanut cropping area (Duncan pers. comm.; Fig. 5 E) or in any field (Fig. 5 F) : pod yields increased as initial nematode population levels increased.

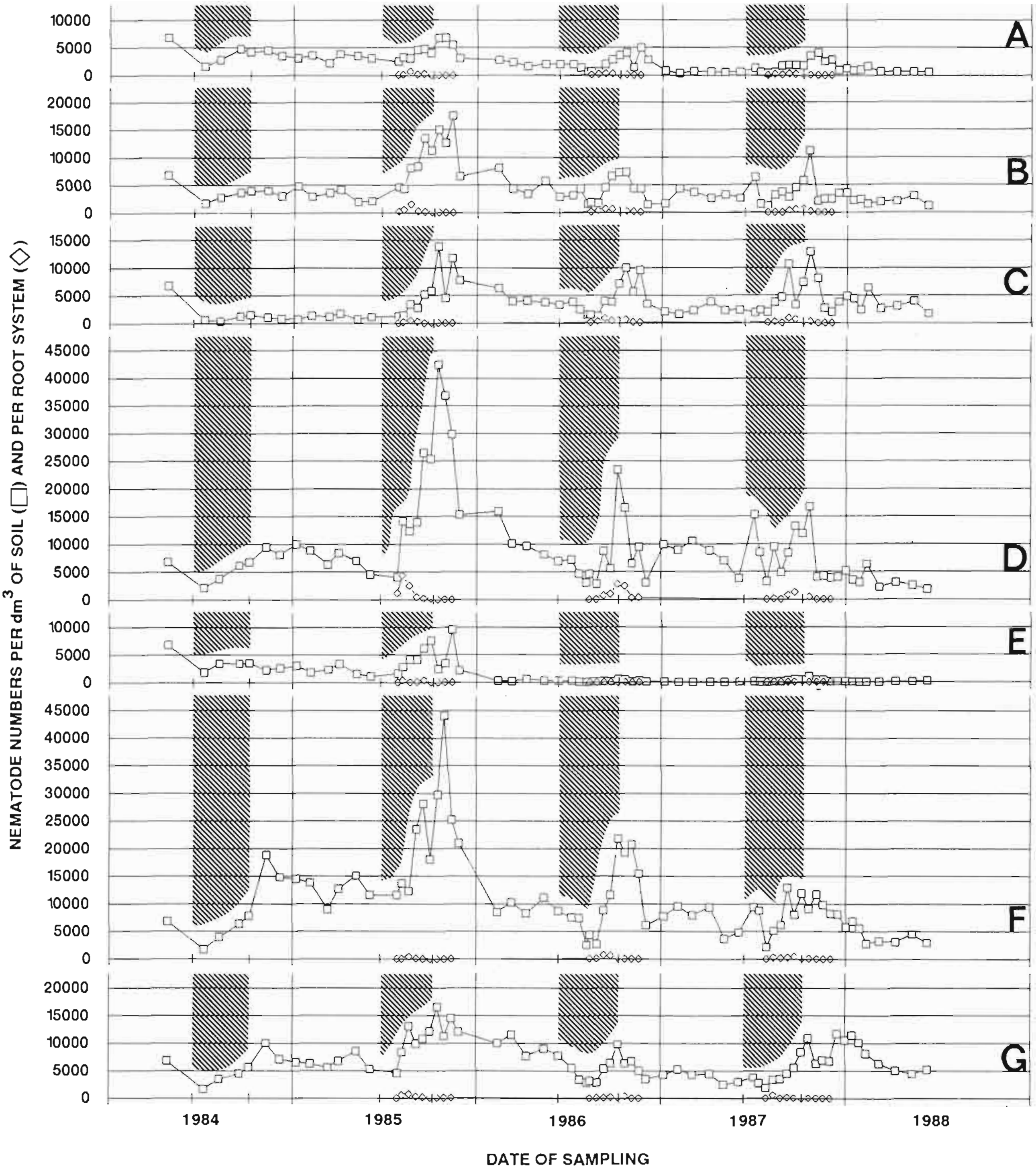

Fig. 2. *Population dynamics of* Scutellonema cavenessi *according to cultural practices (A-G)* (Hatched column : rainy seasons; squares : soil population; diamonds : root population).

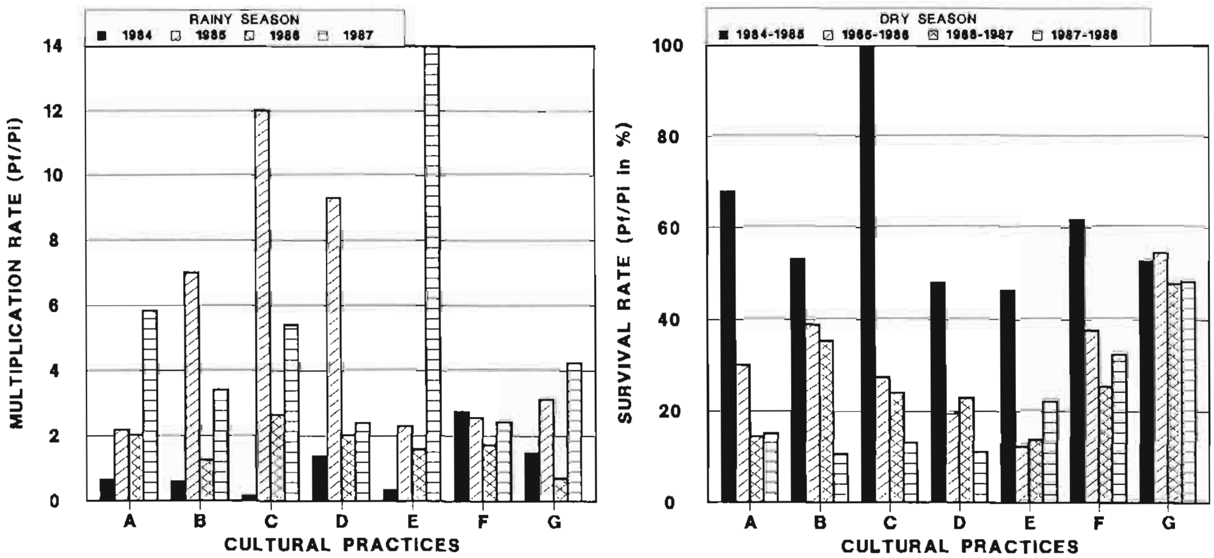

Fig. 3. *Multiplication rates during the rainy seasons and survival rates of* Scutellonema cavenessi *during the dry seasons according to cultural practices (A-G).*

Discussion

The population dynamics of *S. cavenessi* showed two periods related to the climate of the semi-arid area of Senegal : a period of population density decrease during the dry season and a period of increase during the rains. Root population levels never rose above 5000 nematodes per root system as previously described by Sarr *et al.* (1989 *a*) for cowpea crop; this behaviour does not tie in with an explanation of the increase of soil population level during the rainy season by the exit of nematodes from roots at the end of the rainy season (Demeure *et al.*, 1980; Germani, 1981 *a, c*). This increase of soil population level cannot be explained either by nematodes vertical migration in the soil, because vertical distribution of the nematodes during the dry and the rainy seasons is the same. The nematode *S. cavenessi* is characterized by relatively low multiplication rates which is dependent on the host plants and initial population levels as previously recorded (Duncan, 1985). This low reproduction capacity appears to be balanced by high survival rates under anhydrobiosis. The increase of nematode densities from the north to the south of the area appeared to be correlated with the increase of rainfall which affects the soil moisture level and the development of the plant root systems on which the nematodes feed.

The positive correlation between the initial population level of the nematodes and yield of peanut refuted previous statements based on field nematicidal experiments and laboratory tests on the pathogenicity of this species to the peanut crop (Germani, 1981 *b*; Germani *et al.*, 1985). Laboratory tests on the pathogenicity of the species were not conducted with pure populations of *S. cavenessi* but with a mixture of at least four different phytoparasitic species (Germani, 1981 *b*). Additional field and laboratory studies on the effects of nematicides showed that peanut yield increase cannot be explained only by the destruction of the nematode *S. cavenessi*, as nematicides have a stimulating effect on leguminous plant growth (Baujard *et al.*, 1989, 1991; Sarr *et al.*, 1989 *b*). Since other nematode species identified in this area exhibited pathogenic effects on peanut (Baujard & Martiny, 1991, 1993; Baujard *et al.*, 1993), the pathogenicity of *S. cavenessi* to peanut now appears doubtful.

These field studies give the basis for certain hypotheses on the main ecological characteristics of *S. cavenessi* : *i)* the nematode is present in a wide area characterized by sandy soils with relatively high soil temperature and low soil moisture; *ii)* nematode densities are positively correlated with rainfall and probably with soil moisture; *iii)* millet, cowpea, and fallow plants (mainly monocotyledons), are good hosts for the nematode, whereas peanut is a relatively poor host. These hypotheses should be tested under laboratory conditions in order to culture this species to evaluate its pathogenicity to the main pluvial crops of this region.

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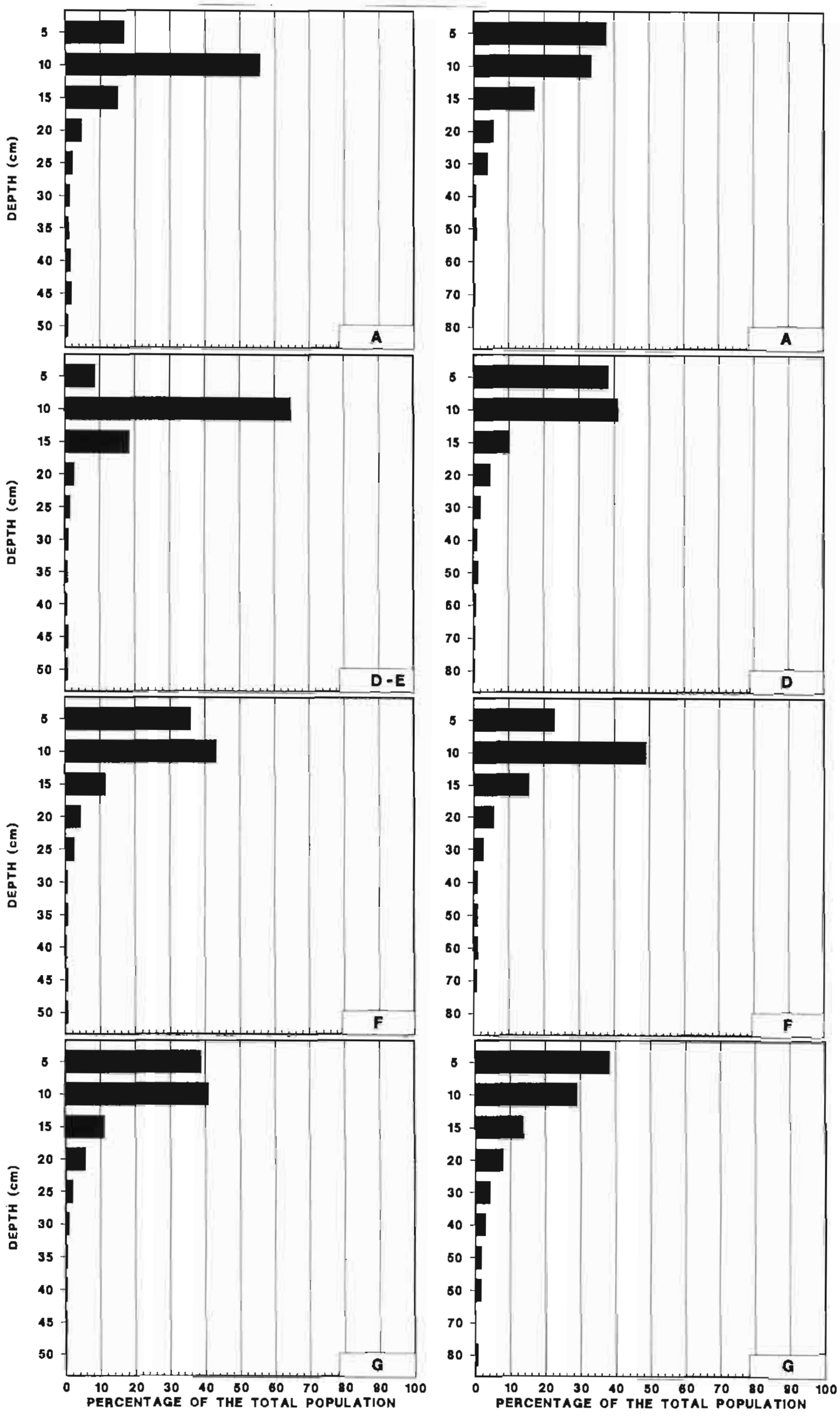

Fig. 4. *Vertical distribution of* Scutellonema cavenessi *during the dry (left column) and the rainy (right column) seasons according to the cultural practices (A-G).*

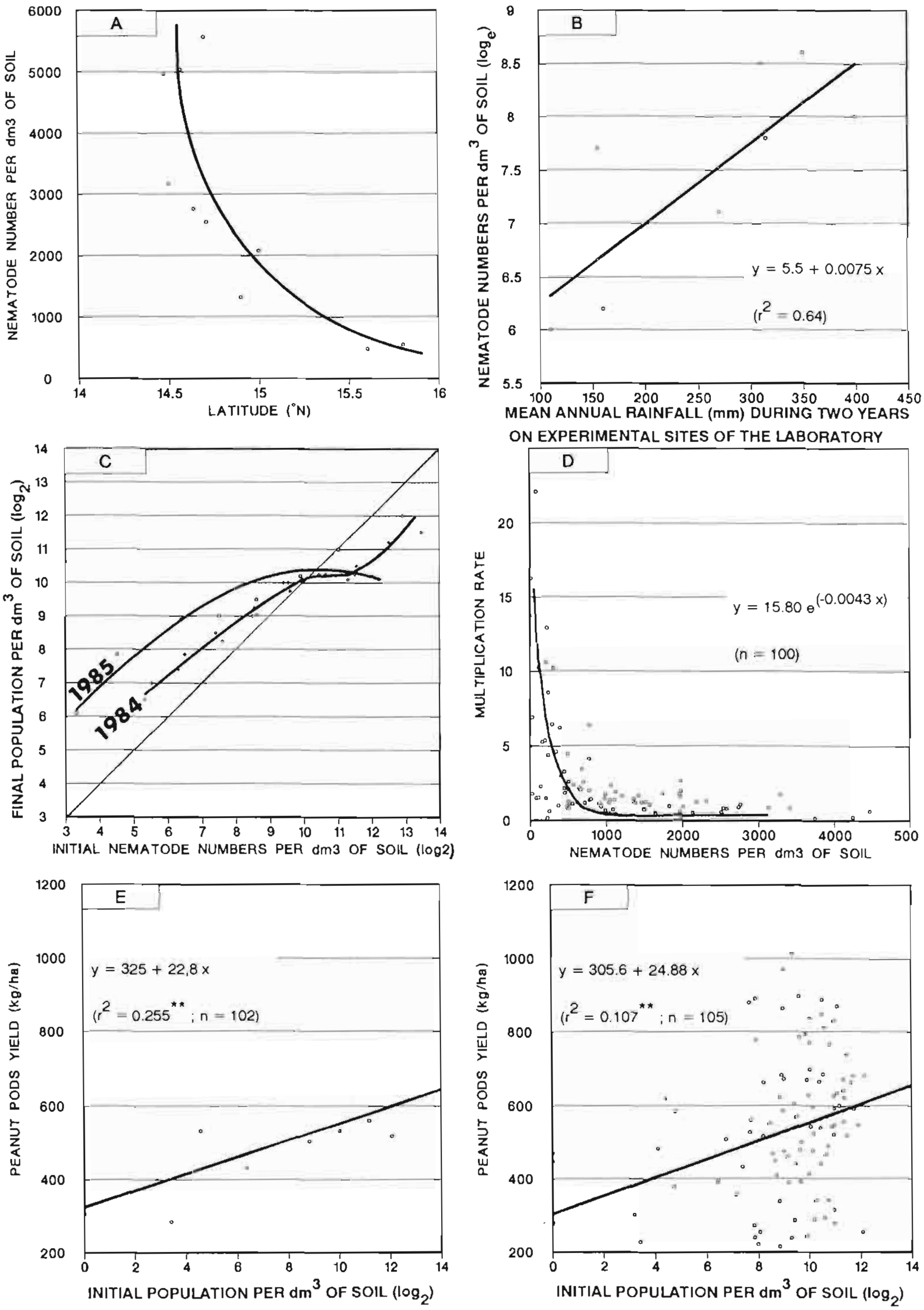

Fig. 5. *Field characteristics of population densities of* Scutellonema cavenessi *on peanut in Senegal. Relations between population densities and geographical location (A) and rainfall (B); Relations between initial population densities and final population densities (C) and multiplication rate (D); Relations between initial population densities and peanut pod yields in the whole of the peanut cropping area of Senegal (F) and in a field (E).*

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