Influence of nematicide placement depth and time of application on treatment efficacy in the Sahelian zone of Senegal

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SUMMARY

Four doses of DBCP were applied in field trials 1, 8, 15, and 22 days following the first seasonal rainfall of 1984 in the Sahelian Zone of Senegal. Application date had no effect on postharvest population levels of *Scutellonema cavenessi* when doses were greater than the recommended rate of 22.5 kg/ha a. i. DBCP. An inverse relationship between mid-season population levels of *S. cavenessi* and treatment date was observed at the low rate of 11.25 kg/ha i. e. DBCP. Although fewer than 1 % of *S. cavenessi* survived in fifteen of the sixteen treatments, peanut plant weights were positively correlated with DBCP dose (r = 0.32*) when data were blocked by treatment date and expressed as arcsin of the proportion of each week's highest yield. DBCP and metam sodium reduced population levels of *S. cavenessi* in a log. linear fashion at two experimental locations when application depths increased from 5 to 15 cm.

RÉSUMÉ

Influence de la profondeur et du moment d'application de nématicides sur l'efficacité du traitement, dans la zone sahélienne du Sénégal.

Lors de traitements en champ dans la zone sahélienne du Sénégal, quatre doses de DBCP ont été appliquées 1, 8, 15 et 22 jours après la première « pluie utile ». Le moment du traitement n'a pas d'influence sur les niveaux des populations de *Scutellonema cavenessi* demeurant après la récolte si les doses utilisées sont plus fortes que celle usuellement recommandée (22,5 kg/ha m. a. DBCP). Une relation inverse entre les niveaux des populations de *S. cavenessi* à mi-culture et le moment du traitement a été observée pour la dose faible (11,25 kg/ha m. a., DBCP). Bien que moins de 1 % des *S. cavenessi* aient survécu dans quinze des seize traitements, les poids des arachides sont en rapport direct avec la dose de DBCP (r = 0.32) si les données sont groupées par date de traitements et exprimées en arcsinus de la proportion de la plus forte récolte de chaque semaine. Le DBCP et le métam sodium réduisent les niveaux des populations de *S. cavenessi* suivant une loi log. linéaire dans deux des sites expérimentaux lorsque la profondeur d'application croit de 5 à 15 cm.

Nematicide and pathogenicity trials during four growing seasons in the Sahelian Zone of Senegal have demonstrated that soil fumigation may be profitable for small plot farmers of peanut, millet, and sorghum (Germani & Gautreau, 1976; Germani, 1979, 1981). Horse-drawn planters, modified to permit simultaneous soil fumigation, are commercially available in Senegal. In spite of favorable field performance (Havard, 1984), the utility of these machines is limited by the manner in which they are currently used. Fumigant application depth of 15 cm gave excellent control of all phytoparasitic nematodes in previous work. However, horses are unable to pull the machines for longer than 3 hr/day, primarily due to the injection shank drag force. It is estimated that reducing the shank depth from 15 to 10 cm reduces the effort needed to pull the machines by nearly half (Havard, 1984).

Another limitation to nematicide use is imposed by rainfall distribution in Senegal. Precipitation is unimodally distributed, occuring between May and October with drought conditions during the winter months. During the drought period, soil moisture falls to less than 0.5 % of soil weight and nematodes exist in an anhydrobiotic state (Demeure, 1980). Thus, soil and biotic conditions are unsuitable for fumigation except during the rainy season. Presently, nematicide applications occur at sowing for several reasons. First, due to limited rainfall (100-400 mm/year), crops are sown with the first

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seasonal rain to maximize yields. This practice permits no time between fumigation and sowing; nevertheless, fumigation at sowing is possible since low doses of dibromo-chloropropane or ethylene dibromide are efficacious and non-phytotoxic to germinating peanuts. Fumigation following harvest has not been attempted because field observations and laboratory studies indicate *Scutellonema cavenessi* Sher, 1964, the most important nematode parasite of the region, is most sensitive to nematicides during the first 72 hr following rehydratation from the annual drought period (Germani & Reversat, 1982, 1983). Recommended fumigation time is thus restricted to the first two to three days following the first seasonal rainfall. This fact, coupled with the large force required to draw the nematicide shank through the soil, severely limits the annual surface area which can be treated by horse-drawn applicators. The cost of these machines to small plot farmers is relatively expensive and expanding their annual utility, by reducing drag or by extending the recommended treatment period, will enhance their value.

This paper presents results of field experiments to measure the efficacy of soil fumigation with two nematicides at three application depths and on the effect of treatment date, measured from the first seasonal rainfall, on efficacy of soil fumigation with DBCP.

Material and methods

APPLICATION DEPTH

Two experiments were conducted to compare efficacy of dibromo-chloropropane (DBCP, 22.5 kg/ha a. i.) and metam sodium (38.25 kg/ha a. i.) applied at depths of 5, 10 and 15 cm. Both nematicides were diluted in water and applied at rates of 100 l mixture/ha. The fumigants were applied with Shell fumigun injectors in the first experiment with injection points at 10 cm intervals on lines 40 cm apart. Plots were 3 m × 3 m with 3 m alleys. The six treatments and an untreated control were replicated six times in a completely random design. Treatments occurred 6 May 1984, 24 hr following the first annual rainfall at Darou Sale. This date was well in advance of the usual rainy season and plots were not sown with peanuts (cv. 55-437) until 21 days later. Nematode soil populations were sampled on 12 May and 16 October by combining twelve, 2.5 × 30 cm soil cores/plot into samples which were mixed and from which 250 cm^3 subsamples were processed (Seinhorst, 1962). Endoparasite populations were sampled on 27 July by extracting nematodes from three root systems/plot (Seinhorst, 1950).

In the second experiment, the same treatments were applied with a horse-drawn applicator-planter at Nebe on 16 June, 48 hr following the first seasonal rainfall. Plots were 3 × 5 m and distances between treatment lines alternated between 45 and 54 cm because the injection shank occurs on one side of the machine's center line. Peanuts were planted by hand the following day. Root populations were sampled on 7 August and soil populations were sampled 12 November and processed as above. The soil types at Darou Sale and Nebe were sand and loamy sand, respectively.

TREATMENT DATE

The experiment was conducted on a loamy sand soil at Nebe. Plots 3 m × 3 m separated by 3 m alleys were treated 24 hr, 8, 15, and 22 days following the first rainfall of 1984 (14 June) to observe whether treatment efficacy varied with treatment date. Doses of 11.25, 22.5, 45, and 90 kg/ha a. i. of DBCP were applied on each date to identify a suitable dose in the eventuality that *S. cavenessi* became less sensitive to nematicide effects as a function of time following the first rainfall. Treatments were applied with Shell fumiguns 15 cm deep each 30 cm on lines 30 cm apart. Nematicide doses were mixed with water and applied at a rate of 500 l mixture/ha. Treatments were replicated three times in a randomized complete block design. Peanuts (cv. 55-437) were planted immediately following treatment each week. To simulate standard field practices, plots were not cultivated for weed control prior to treatment and sowing. Weeds were removed by hand at intervals following peanut emergence. Nematode population levels were estimated from samples obtained prior to the first rainfall by combining six subsamples/plot taken to a depth of 15 cm, and samples were subsampled and extracted as previously described. Nematode populations in peanut roots were estimated 50 days following sowing and final populations were estimated from soil samples taken seven days following harvest. Peanuts were harvested 90 days after sowing. Haulms and seeds were dried and weighed. Yield data were blocked by treatment week, due to variable rainfall, and expressed as proportions of each week's highest yielding plot. Transformed (arcsin) yield data were regressed against nematicide dose.

Results

APPLICATION DEPTH

Root populations of *S. cavenessi* measured 50 days after sowing were greater at the 5 cm depth than at 10 or 15 cm depths at Darou Sale for both nematicides (Tab. 1). No consistent treatment differences were detected with 50 day root population levels at Nebe. Post-harvest soil population levels of *S. cavenessi* were negatively correlated with placement depth for DBCP at both locations and for metam sodium at Nebe (Fig. 1). At Darou Sale, metam sodium only reduced population

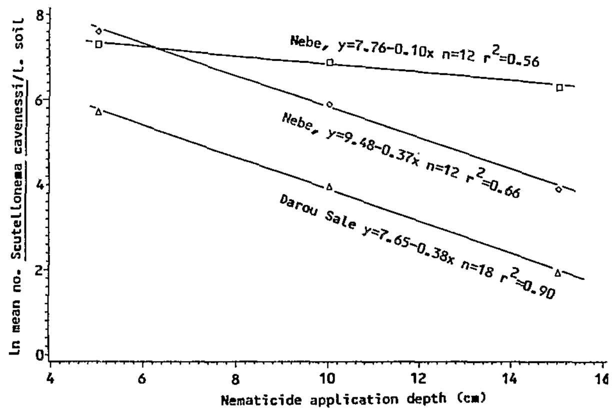

Fig. 1. Postharvest population levels (ln) of *Scutellonema cavenessi* following soil fumigation at different depths with metam sodium (squares) or DBCP (diamonds and triangles).

Table 1

Mean population levels of *Scutellonema cavenessi*/100 g peanut roots 50 days following sowing. Numbers in same group followed by different letters are significantly different ($p = 0.05$) according to Duncan's multiple range test on ln transformed data.

Nematicide	*Depth* (*cm*)	*Location* *Darou Sale*	*Nebe*
Metam sodium	5	6 741 a	9 498 a
	10	3 837 a	8 056 a
	15	3 562 a	3 274 a
DBCP	5	946 a	697 a
	10	52 b	282 a
	15	100 b	958 a

levels with respect to control plots (average final population = 1,905/l soil) by 25, 48, and 35 % at depths of 5, 10, and 15 cm, respectively. By contrast, DBCP placed at the 15 cm depth at Darou Sale reduced final soil populations of *S. cavenessi* by more than 99 % with respect to control plots. The degree of placement depth effect, as measured by the slope of regression lines fitted to log transformed data, was the same at both locations where DBCP was used (Fig. 1). The sampling strategy for soil populations was more precise than that for root populations; average coefficients of variation were 81 and 162 ($p = 0.05$), respectively.

TREATMENT DATE

There were no effects of treatment date on root or soil population levels of *S. cavenessi* when doses of DBCP were greater than 11.25 kg/ha a. i. (Tab. 2, Fig. 2). An inverse relationship between treatment date following the first seasonal rainfall and root populations 50 days after sowing existed when the low rate of 11.25 kg/ha a. i. was used (Fig. 3). This relationship was not noted in the post-harvest soil population levels although final populations in plots treated on the day following the first seasonal rainfall were higher than those treated on subsequent dates for the 11.25 kg/ha a. i. treatment (Fig. 2).

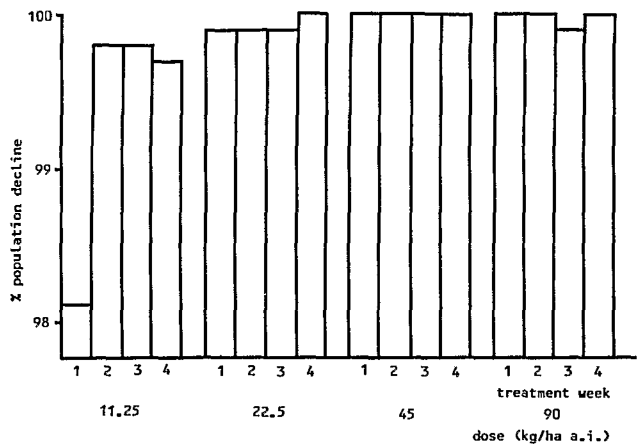

Fig. 2. Effect of treatment date on reduction of postharvest *Scutellonema cavenessi* soil population levels from preplant population levels.

Table 2

Population levels of *Scutellonema cavenessi*/100 g peanut roots 50 days following sowing. Mean values followed by standard errors ($n = 3$).

Days following first rainfall	*Dose (DBCP kg/ha a. i.)* 11.25	22.5	45	90
1	827 (577)	21 (21)	0	0
8	135 (45)	0	19 (19)	0
15	44 (44)	0	36 (36)	0
22	0	0	0	63 (63)

Plant growth declined with treatment-planting date. The linear correlation coefficient between top growth and planting date (days following the first rainfall) was — 0.82** and between seed yield and planting date it was — 0.76**. A positive linear correlation (arcsin y = 0.66 + 0.005 dose DBCP, r = 0.32*) existed between 90 days peanut vegetative growth and dose of DBCP when data were blocked according to planting date and expressed as proportion of the greatest growth for a given date.

Discussion

The results obtained suggest that during the rainy season in Senegal the efficacy of DBCP applied at the recommended rate of 15 l/ha (22.5 kg/ha a. i.) is not influenced by treatment date (Fig. 2). In contrast, reduction of the recommended nematicide placement depth (15 cm) is likely to reduce the product efficacy (Fig. 1).

The hypothesis that treatment efficacy of 15 l/ha DBCP is inversely related to time between the first seasonal rainfall and nematicide treatment date (Germani & Reversat, 1983) was based on field observations (Germani & Reversat, 1982) and on laboratory experiments (Germani & Reversat, 1983) that clearly demonstrated *S. cavenessi* is more susceptible to DBCP toxicity during a short period following anhydrobiosis. Nevertheless, data from those experiments appear to be consistent with the present results. Germani and Reversat (1983) noted that, regardless of whether nematodes were treated immediately or twelve days following rehydratation, mortality increased with time following DBCP treatment, a frequent field observation (G. Germani, P. Baujard & L. Duncan, unpublished data), and that nematodes surviving treatment were reproductively sterile. Nematode population levels were monitored for fourteen days following treatment in that study compared with 50 and 97 days in the present work. Thus, while DBCP is most toxic to *S. cavenessi* during rehydration from the anhydrobiotic state, there is no evidence that 15 l/ha DBCP in the field will not eventually reduce *S. cavenessi* populations to non-detectable levels (Fig. 2), regardless of treatment date during the rainy season. The present data suggest that under field conditions, nematode survivorship may actually be enhanced by early treatment dates when low doses (11.25 kg/ha.a.i.) of DBCP are used (Fig. 3). Since weeds were not cultivated in treatment plots until the date of nematicide treatment, it is possible that nematodes which established themselves in weed roots were killed when roots were removed from the soil during the later treatment dates. If the *S. cavenessi* mortality rate is ca. 98 % when 11.25 kg/ha a. i. DBCP is used under these conditions, weed cultivation may explain the additional mortality at later dates.

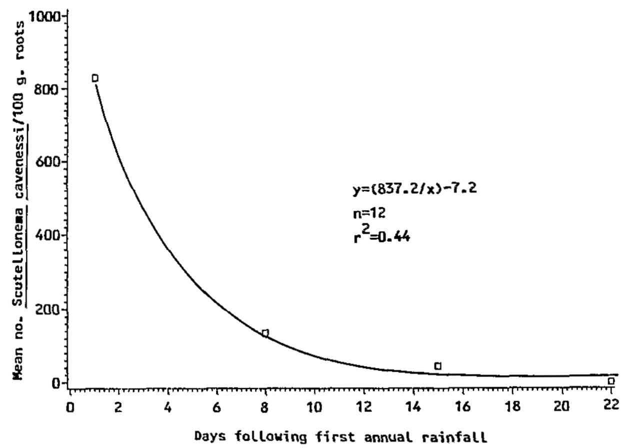

Fig. 3. Effect of treatment date on population levels of *Scutellonema cavenessi* in peanut roots 50 days after sowing.

Finally, numerous studies (Germani & Gautreau, 1976; Baujard, Duncan & Germani, 1984; Baujard *et al.*, 1985) indicate the unlikelihood that 15 l/ha DBCP may be sufficient to eradicate populations of *S. cavenessi* in conditons other than carefully controlled small plot experiments. This fact mitigates the importance of slight effects that variables such as treatment date may have on treatment efficacy.

There are few if any reports that DBCP augments plant growth by means other than nematode suppression. The positive correlation in the treatment date experiment between peanut plant weights and DBCP dose is surprising since phytoparasitic nematodes were reduced to extremely low or non-detectable levels in all replicates of all treatments. Recent investigations (Duncan, 1985) suggest that *S. cavenessi* is considerably more pathogenic on millet and cowpea than on peanut. If the present results are supported by further research, they would help explain growth augmentation in peanuts following treatment by DBCP in terms other than mere suppression of nematode populations.

Références

BAUJARD, P., DUNCAN, L. & GERMANI, G. (1984). *Les traitements nématicides dans le Bassin arachidier du Sénégal.* Rapport Convention DPU/ORSTOM/FAC. ORSTOM, Dakar, 41 p.

BAUJARD, P., DUNCAN, L., MARTINY, B., PARISELLE, A. & SARR, E. (1985). *Les traitements nématicides dans le Bassin arachidier du Sénégal. Résultats de la campagne 1984.* Rapport Convention ORSTOM/SODEVA. ORSTOM, Dakar, 56 p.

DEMEURE, Y. (1980). Biology of the plant parasitic nematode *Scutellonema cavenessi* Sher, 1964 : anhydrobiosis. *Revue Nématol.*, 3 : 283-289.

DUNCAN, L. (1985). Quantitative host-parasite relationships in a dryland farming region of Senegal. *J. Nematol.*, 17 : 519 [Abstr.].

GERMANI, G. (1979). Action directe et rémanente d'un traitement nématicide du sol sur trois cultivars d'arachide au Sénégal. *Oléagineux*, 34 : 399-404.

GERMANI, G. (1981). Pathogenicity of the nematode *Scutellonema cavenessi* on peanut and soybean. *Revue Nématol.*, 4 : 203-208.

GERMANI, G. & GAUTREAU, J. (1976). Résultats agronomiques obtenus par des traitements nématicides sur arachide au Sénégal. *Cah. ORSTOM, Sér. Biol.*, 11 : 193-202.

GERMANI, G. & REVERSAT, G. (1982). Effet sur les rendements de l'arachide au Sénégal de deux produits nématicides, DBCP et EDB, et d'un amendement organique. *Oléagineux*, 37 : 521-524.

GERMANI, G. & REVERSAT, G. (1983). Effet du dibromochloropropane sur quelques espèces de nématodes reviviscents, parasites de l'arachide au Sénégal. *Revue Nématol.*, 6 : 73-78.

SEINHORST, J. W. (1950). De betekenis van de grond voor het optreden van aanstasting door het stengelaaltje (*Ditylenchus dipsaci* (Kühn), Filipjev) *Tijdschr. Pl. Ziekt.*, 56 : 291-349.

SEINHORST, J. W. (1962). Modifications of the elutriation method for extracting nematodes from soil. *Nematologica*, 8 : 117-128.

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