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STUDIES ON THE HOST RANGE OF *DITYLENCHUS DIPSACI* IN MOROCCO

by
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Summary. Severe damage due to *Ditylenchus dipsaci* was observed on garlic, onion, peas, alfalfa, sugar beet and oat during surveys conducted in different regions of Morocco. The infestation rate in these crops was high and ranged from 55 to 100%. The nematode reproduces very well on garlic on which more the 11,000 specimens per plant were found. Eleven out of sixty weed species found in fields of faba bean were infested at different extend by the nematode. *Avena sterilis*, *Orobanche crenata*, *Vacaria pyramidata* and *Verbena supina* were good hosts for the giant race. Measurements of the lengths of adult and pre-adult stages, extracted from the surveyed crops, appear to be the normal race of the nematode; the measurements of nematodes extracted from *V. pyramidata* appear to be the giant race.

The stem nematode *Ditylenchus dipsaci* (Kühn) Filipjev is polyphagous and can infest more than 450 different plant species including cultivated and weed plants (Goodey *et al.*, 1965). Several authors (Winslow, 1960; Sturhan, 1971; Sturhan and Brzeski, 1991) reported thirty biological races, according to host preference. Knowledge of the host status of *D. dipsaci* is essential for the success of control measures relying, mainly, on plant resistance and crop rotation.

Information on the host-range of the nematode is scanty in Morocco. However, the nematode was reported in association with collar rotting of sugar beet for the first time by Schlüter (1972) in Tadla and low Moulouya regions and few years later a severe infestation was also recorded on faba bean in several areas of the country (Schreiber, 1978). Further information is available concerning the host status of the nematode in Morocco.

The objective of this investigation was to identify other plant hosts, cultivated crops or weed plant species which may play an important role in persistence and multiplication of *D. dipsaci*.

Materials and methods

Surveys on the distribution and incidence of the nematode were carried out in fields of the main producing regions of garlic (*Allium sativum* L.), onion (*A. cepa* L.), sugar beet (*Beta vulgaris* L.), alfalfa (*Medicago sativa* L.), oat (*Avena sativa* L.), corn (*Zea mays* L.) and peas (*Pisum sativum* L.) from 1991 to 1999 (Fig. 1). Surveys were made during the maturation stage of each crop species. Three to five plants in each field were collected from patches where plants showed typical symptoms of the nematode attack. Aerial plant parts of each sample

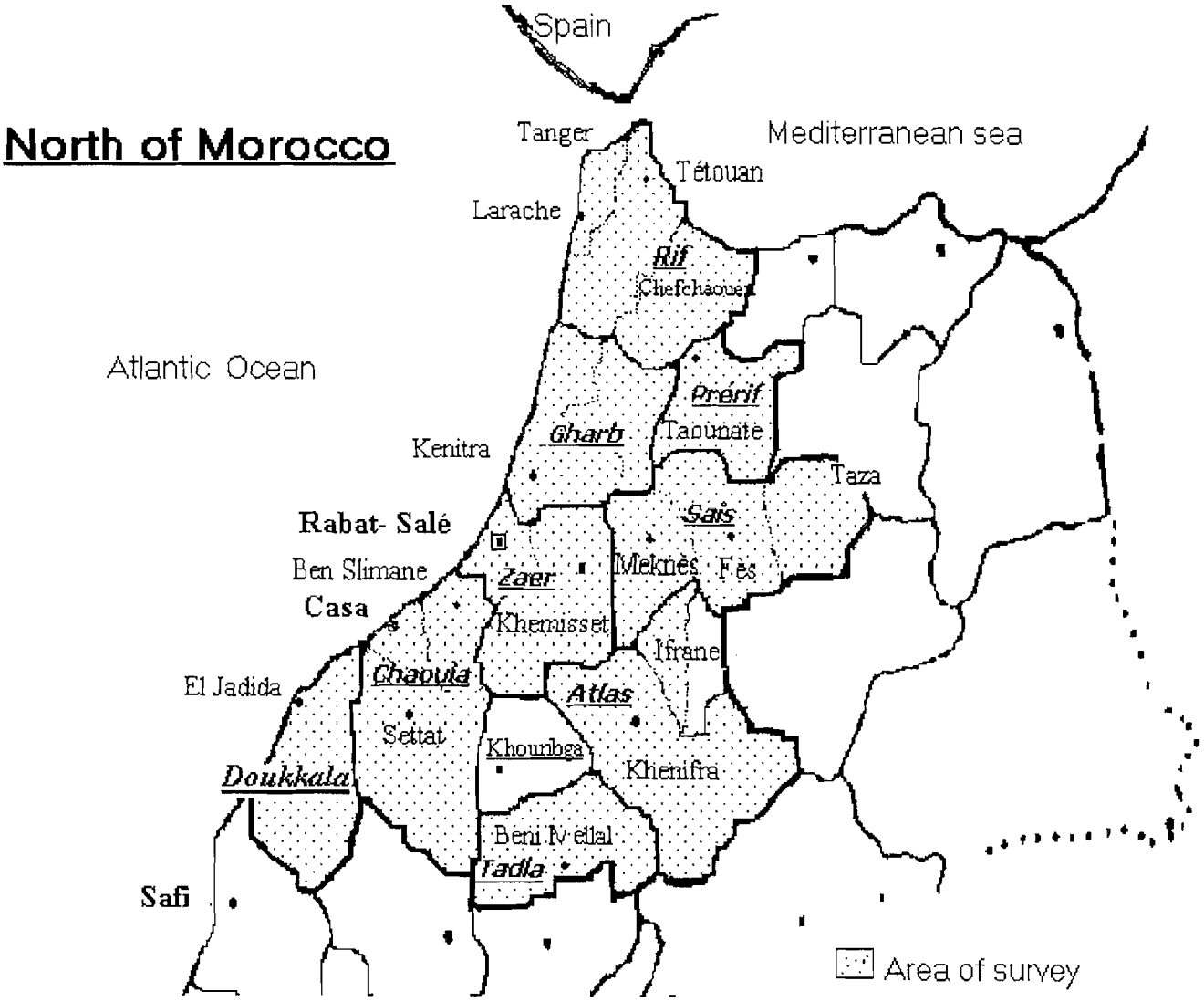

Fig. 1 - Survey area of *Ditylenchus dipsaci* in Morocco.

were cut into small pieces of 1-3 cm long, thoroughly mixed and a sub-sample of 5 g each was crushed into 200 ml of water and incubated for 48 h; nematodes were then counted. Nematodes from different samples were fixed in a formaldehyde and acetic acid solution and thirty specimens for each of the pre-adult, female and male stage were measured.

Weed samples were also collected from faba bean infested fields and nematodes extracted.

The host range investigation of the "giant race" of the nematode was conducted in pot and in field experiments.

Two pot experiments were undertaken under field conditions. Three litres or 550 cm^3 plastic pots were filled with steam sterilised sandy soil in 1996 or 1999, respectively. Ten "giant race" populations of *D. dipsaci* identified by length measurements were inoculated in the two tests (Table IV). Three pots were used for

each nematode population and tested plant species (Table V) and they were artificially inoculated with 400 specimens/pot and laid on the soil during the experimentation period. Pots were sown in November and the plants were maintained till June when they were harvested.

The field experiment was conducted at Kenitra in plots artificially infested six years before with a population of the "giant race" collected in Dar Bouazza region. Different plant species (Table V) were sown in rows long 40 cm and spaced 50 cm apart. The plots were distributed in a randomised block design with four replications. Faba bean (*Vicia faba* L.) cv. Aguadulce was used as susceptible control and was planted every three rows. Irrigation, fertilisation and pest control were made as required. Weed plant species present in the field were collected and processed for nematode extraction.

TABLE I - *Distribution and severity of infestation of* Ditylenchus dipsaci *on different crops observed during the surveys conducted in Morocco.*

Crop	Sampling regions	Period of survey	Samples collected	% of infested samples	Nematodes/plant
Chickpea	Zaere, Sais Gharb, pré-Rif, Chaouia	1991-1999	123	11	6 (13)*
Lentil	Zaere, pré-Rif, Chaouia	1991-1994	35	5	4 (11)
Pea	Zaere, Sais, pré-Rif	1998-1999	7	100	1281 (3015)
Garlic	Sais	1993-1994	9	100	11,880 (28,992)
Onion	Sais, Zaere, Haouz, Tadla	1993-1995	30	57	910 (20,024)
Alfalfa	Gharb, Tadla Haouz, Rich	1994-1999	25	67.8	2426 (12,836)
Sugabeet	Gharb, Tadla	1993-1995	30	51.7	99 (675)
Oat	Sais, Zaere, Gharb	1994-1999	14	55	6853 (26,924)
Corn	Tadla, Haouz	1994-1995	6	25	9 (54)

* = In parentheses the maximum number of specimens per plant.

TABLE II - *Length of specimens of* D. dipsaci *extracted from different plant species.*

Plant species	Nematode length (µm)		
	J4	Male	Female
Onion	996	1258	1324
Garlic	965	1209	1283
Oat	946	1282	1332
Sugar beet	943	1309	1371
Alfalfa	941	1265	1355
Pea	988	1125	1313
Vacaria pyramidata	1175	1406	1531
Faba bean ("normal race")	951	1294	1318
Faba bean ("giant race")	1196	1445	1552

Results and discussion

The survey showed that typical symptoms of the nematode attacks were evident on all crops except corn. Young infested plants of garlic and onion wrapped up like a corkscrew and their

TABLE III - *Weed plant species infested by* D. dipsaci *in fields cultivated with faba bean.*

Plant species	Number of samples				Nematodes/plant	
	Collected	Infested	"Giant race"	"Normal race"	"Giant race"	"Normal race"
Amni visnaga (L.) Lam.	9	4	4	–	24	
Avena sterilis L.	27	2	1	1	110	247
Calendula bicolor Raf.	6	1	1	–	5	–
Hordeum marinum Huden	4	1	1	–	20	–
Lolium rigidum Gaudin	7	1	1	–	17	–
Orobanche crenata Forsk.	19	9	8	1	130	10
Papaver argenome L.	13	4*	–	1	–	20
Rumex pulcher L.	6	2*	1	–	27	–
Sinapis arvensis L.	16	8*	2	1	25	15
Triticum aestivum L.	16	2	2	–	12	–
Vacaria pyramidata L.	2	1	1	–	1000	–
Verbena supina L.	5	1	1	–	130	–

*: others populations were not caractérized.

growth was reduced in comparison to healthy plants. During the growing season, infested plants showed yellowing, stunting and twisting symptoms. In some cases, there was a hypertrophy at the base of plants. Shattering also occurred on severely attacked plants and later at the harvest time, rot and putrefaction smell were present. These symptoms were often observed in Saïs and Zaere regions where garlic and onion are common. Growth reduction was also observed in infested fields in Bhalil area on the border of middle Atlas and Saïs plain while attack of the nematode was rare in Tadla and Haouz areas.

About 11,880 and 910 nematodes were extracted from onion and garlic plants, respectively (Table I).

Plant distortion and yellowish were observed on infested sugarbeet plants at seedling stage. They became more evident later when the basal leaves were yellow and with necrosis. Longitudinal section of sugarbeet infested roots showed a brownish spot starting from the collar to the bottom of root, which became spongy when the infestations were more severe. These symptoms were observed in all regions investigated but only few nematode specimens/plant were extracted from sugarbeet.

Ditylenchus dipsaci was also observed in oat fields with severe damages and in some cases, such as in Saïs and Zaere regions, the crop was completely destroyed. Severe attacks were also found in Zaere fields in 1999 with stunted plants and increase of tillage.

The symptoms of the nematode attack were evident on alfalfa, whose plants were completely destroyed, in Rich region in 1999 with an average of 2,426 specimens/plant. No evident symptoms of the nematode attack were found on the crop in the remaining regions.

No symptom was also observed on corn in Tadla and Haouz regions with 25% of infested samples and 9 nematodes/plant (Table I).

Few specimens of the nematode were extracted from chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Medik) (Table I).

Nematode length measurements of pre-adult, females and males, collected from different plants, ranged from 941 to 996, 1,283 and 1,371 and 1,125 and 1,306 µm, respectively and were

similar to those of "normal race" attacking faba bean (Table II).

Sixty weeds species were taken from faba bean fields. Symptoms of *D. dipsaci* attacks of the "giant race" were only detected on *Orobanche crenata* Forsk. and *Vicaria pyramidata* L. in the same field at Douyet region (Table III). All the following weeds, *Ammi visnaga* (L.) Lam, *Avena sterilis* L., *Calendula bicolor* Raf., *Hordeum marinum* Huden, *Lolium rigidum* Gaudin, *O. crenata*, *Rumex pulcher* L., *Sinapsis arvensis* L., *Triticum aestivum* L., *V. pyramidata*, *Verbena supina* L., but *Papaver argenome* L. were infested by the "giant race". The "normal race" of the nematode was found in plants of *A. sterilis*, *O. crenata*, *P. argenome* and *S. arvensis* with different level of density.

During the first year of the host range experiment (1995-96), rainfall was well distributed from sowing (November) to the end of the experiment. The average temperatures of November varied from 8 to 20 °C. These conditions were very favourable for the penetration and the multiplication of the nematode into the broad bean plants. Necrosis, first symptoms of attack of *D. dipsaci*, started to appear on this crop from the third week after inoculation. Thereafter, the symptoms developed gradually to become very apparent towards the end of March. In the second year of experimentation (1998-99), rainfall was practically null at the time of sowing, therefore several irrigations were made to enhance nematodes penetration and multiplication. The first symptoms appeared later compared to the first experimentation and they were very visible on the broad bean plants from the second week of April.

Faba bean was the only plant species severely attacked by the giant race of *D. dipsaci* in the pot and field experiments while on the remaining plant species tested symptoms and nematode numbers were negligible (Table V). This confirms the specificity of this race also in Moroccan conditions (Sturhan, 1964). This race was reported in North Africa region since the end of the last century (Debray and Maupas, 1896). Recent surveys indicated a large distribution of this race in broad bean fields causing significant damage. Seed is the principal mean of dissemination of this race in these areas (Caubel *et al.*, 1997).

The weed species *H. marinum*, *Plantago amplexicaulis* (L.) Cav., *Emex spinosa* (L.) Campd, *Calendula arvensis* L., *Chrysanthemum segetum* L., *Diplotaxis catholica* (L.) Dc., *Rumex crispus* L. and *Bromus rigidus* Roth. were free of nematode attack in the field experiment at Kenitra.

The attack of the "normal race" of *D. dipsaci* on garlic, onion, oats, alfalfa and peas is reported for the first time in Morocco. Severe damage on garlic and onion was observed in areas of the country where the crops were cultivated intensively and for several consecutive years. Severe yield losses of alfalfa was noticed in Rich area near Errachidia while no visible damage on the crop was observed in Gharb, Tadla and Haouz.

Oat was very sensitive to attack of the normal race of *D. dipsaci*. However, despite the presence of this race in *V. faba* fields in pre-Rif, infestations were very low. This may be due to the specialisation of *D. dipaci* normal race attacking oats.

TABLE IV - *Populations of the "giant race" of* D.dipsaci *used in the pot experiment.*

Population	Origin (region)	Year of experiment
P1	Marchouch (Zaere)	1996
P2	El Karia (pré-Rif)	1996
P4	Ain Aziz (Zaere)	1996
P5	Oulad Abou (Chaouia)	1996
P11	El Menzeh (pré-Rif)	1999
P12	Maaziz (Zaere)	1999
P13	Oued Amlil (pré-Rif)	1999
P14	Douyet (Saïs)	1999
P15	El Gara (Chaouia)	1999
P16	Douyet 2 (Saïs)	1999

TABLE V - *Nematode extracted from cultivated plant species inoculated with different populations of the "giant race" of* D. dipsaci *in pot and field experiments in Morocco.*

Plant species	Field experiment	Pot experiments															
		1996					1999										
		Nematode populations used															
	Dar Bouazza	P1	P2	P3	P4	P5	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
Faba bean (*Vicia faba* L.)	26,260	1422	1835	617	1581	3219	1505	1487	2762	989	3066	419	3193	2237	222	292
Chickpea (*Cicer arietinum* L.)	4	0	0	0.6	6.6	0	0.72	0.78	0	0.22	0	–[a]	–	–	–	–
Peas (*Pisum sativum* L.)	3	0	0	0	3.1	0	–	–	–	–	–	–	–	–	–	–
Lentils (*Lens culinaris* Medik.)	2	0	0.1	1.1	10	0.2	3.44	1.67	1.22	4.67	1.78	–	–	–	–	–
Alfalfa (*Medicago sativa* L.)	0	0	0.6	0.2	0	0	–	–	–	–	–	–	–	–	–	–
Durum wheat (*Triticum durum* Desf.)	0	0.2	0.2	0	0.1	–	–	–	–	–	–	–	–	–	–	–
Bred wheat (*T. vulgare* Vill.)	0	0	0	0	4.3	0.4	0.11	0	0.44	1	1.44	–	–	–	–	–
Oats (*Avena sativa* L.)	1	0	0	0	0	0	5.89	4.89	5.11	1.78	3.89	6.5	2.67	3.33	2.83	2
Garlic (*Allium sativum* L.)	0	–	–	–	–	–	2.78	2.67	4.33	3.11	5.22	6.83	4	3.17	9	4.17
Onion (*A. cepa* L.)	–	0	0	0	0	0	0.11	0.33	1.44	0.67	0.67	1.67	0.83	1.83	3.3	1
Corn (*Zea mays* L.)	3	0.3	0	0	0	0	1.22	0.44	1.11	1.56	0.89	–	–	–	–	–
Sugar beet (*Beta vulgaris* L.)	0	0	0.4	0	1.8	0	0	0.78	1.11	0	0	0	0.83	0	0	0
Squash (*Cucurbita pepo* L.)	0	0	0	0	0	0	–	–								–
Barley (*Hordeum vulgare* L.)	–	0	0	0	0	0	–	–	–	–	–	–	–	–	–	–
Tomatoes (*Lycopersicon exculentum* Mill.)	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carrot (*Daucus carota* L.)	7	0	0.4	0.4	1.8	1	–	–	–	–	–	–	–	–	–	–

[a] = Not detected.

Sugarbeet suffered severe damage by the attack of the nematode but few nematodes were extracted from plant tissues. High humidity conditions characterising coastal areas and rainy years seem to favour this nematode attacks.

A large number of nematodes were found in aerial plant part of pea with negligible symptoms. The vegetative period of this crop (three months) constitutes an impediment for the stem nematode development and reproduction. Weather conditions at the end of winter and the beginning of spring are also unfavourable for this nematode. *D. dipsaci* is a real pest to peas in other countries (Hooper, 1972).

Attacks on corn were absent and a few number of nematodes were recovered from samples of this crop. Cultivation of corn from the end of spring and during summer in Morocco limits the stem nematode development.

Several weeds, including *Orobanche*, were found good hosts for *D. dipsaci* normal race and, therefore, are important for nematode reproduction and persistence into the soil. Many other weed species were reported as hosts for *D. dipsaci* normal race (Barker and Sasser, 1959; Perret, 1971; Wilson and French, 1975). However, the host-range of the giant race seems to be limited (Hooper and Clayde, 1981; Hanounik and Sikora, 1989).

Infestation and damage to susceptible crops is correlated also with rainfall, air humidity, type of irrigation, temperature (favourable is 15-20 °C) and residue of infested plant parts. Therefore, propagation of plant materials free from the nematode, especially seeds, is a prerequisite to avoid severe damages to crops. Good weed control is also recommended to avoid

built up of nematode population densities at damaging level.

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