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Root - knot nematodes on summer vegetables in North Tunisia [1]

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Summary

The influence of different factors on the root-knot nematode infestation and on the yield of tomato have been examined: date of planting, cultivar choice, rotation scheme and soil disinfestation. It was found that the earliest planting date gave the highest yield but also the most severe root galling on susceptible tomato cultivars. A cropping sequence where wheat is alternated with tomatoes was not sufficient for reducing root-knot nematode population to a level permitting the cropping of a susceptible tomato cultivar. Long rotations with non host crops should be used. Soil treatment with certain nematicides significantly reduced the root galling and improved the yield.

Résumé

*L'influence de plusieurs facteurs (dates de plantation, variétés, rotation et traitements du sol) sur l'infestation par les nématodes des racines noueuses (*Meloidogyne *spp.) et sur le rendement d'une culture de tomate a été examinée. Les plantations les plus précoces donnaient le meilleur rendement mais avaient également les racines les plus infectées. Un schéma de rotation dans lequel une culture de tomate alternait avec du blé n'a pas réduit suffisamment la population des nématodes dans le sol pour permettre la culture d'une variété de tomate sensible aux nématodes. Il faudrait avoir recours à des rotations de longues durées avec des plantes non sensibles.*

La désinfection du sol a réduit significativement l'infection dans les racines et a amélioré le rendement.

Introduction

Root-knot nematodes are serious pests in the mediterranean region (2). On vegetable crops *Meloidogyne incognita* (Kofoid et White) Chitw., *M. javanica* (Treub) Chitw. and *M. arenaria* (Neal) Chitw. are predominant and Tunisia is not an exception.

Processing tomatoes, sweet and hot peppers, and cucurbits are the most important summer vegetable crops in the lower Medjerda Valley in North Tunisia. Soils are very heavy (*) and difficult to prepare during winter when rainfall is frequent and mean soil temperatures reach 8-9°C. During June, July and August mean soil temperatures raise to over 30°C at 30 cm depth. Summer crops are planted from March to May. The canning industry requires tomato cultivars possessing a high percentage of solids and low pH to facilitate processing. Cultivars with resistance to soil pests are not widely used by the farmers. For pepper cultures a choice is made among local sweet or hot peper cultivars. Cucurbit cultivars are of Tunisian or foreign origin. Crop rotations are not practiced or when utilized include root-knot nematode host plants. Sometimes crop rotation with wheat or orther cereals is practiced.

Root-knot nematodes are relatively widespread in the lower Medjerda Valley and can cause serious damage to vegetables, particularly to tomatoes. This prompted the investigations on various ways of controlling the nematodes. The present paper reports the results of studies done during the years 1972 - 1976. The objectives were: (1) to determine the influence of the date of planting of a summer tomato crop on fruit yield and root-knot nematode infestation: (2) to compare the resistance and agronomic qualities of selected tomato cultivars: (3) to evaluate the influence of a rotation scheme on the yield of a tomato crop and (4) to assess the effectiveness of soil disinfection on the root-knot nematode infection and yield of tomatoes.

(1) Station d'Appui Nebhana - Projet Tuniso-Belge - B P. 57 Monastir - Tunisia

* The soil characteristics at the Station d'Appui Medjera are: $<2\mu$: 27.8%, 2-20μ: 18%, 21-50μ: 28.8%; $>50\mu$: 25.4%, organic matter 3.3%; Tt: 24.2 and pH KCl. 7.3.

Materials and methods

Influence of date of planting and cultivar

An experiment (split-plot design) was set up at Saïda in a filed uniformly infested with *Meloidogyne incognita* (Kofoid et White) Chitw. Four dates of planting were chosen : (a) 17 April, (b) 5 May, (c) 26 May and (d) 12 June. To determine the impact of the root-knot nematodes the following tomato cultivars were selected : Roma VF, Roma VFN, St Pierre and Piersol. The first 2 are semi-late cultivars and differ only in their susceptibility or resistance to root-knot nematodes. The last 2 cultivars St Pierre and Piersol differ in the same way but Piersol also possesses *Verticillium* and *Fusarium* resistance. Thirty plants were planted per plot, each measuring 21.6 m² (3,6 x 6 m). Observations on the yield and fruit quality were made on 15 plants; the remaining 15 plants served for nematological observations.

Resistant tomato cultivars

Three experiments (random bloc design) with 5 replications were installed in root-knot infested fields of farms in the lower Medjerda Valley. Each plot (2,4 x 4 m) was planted with 20 plants. Observations were made on the root-knot infection and the yield. To have an idea on the total solids and pH, two important characters for the canning industry, a sample of 10 harvested fruits was mixed in a Waring Blendor and the juice obtained was immediately tested on a refractometer and pH-meter.
Another experiment was conducted on a root-knot nematodes infested field at the village of Saïda. Sixteen different tomato cultivars were planted on 2 different dates : 15 April and 8 May. The cultivars were : Heinz 1706, Roma VFN, Bog AT, Cal J, Super Roma, Super California, VF 198, Roma VF, Canatella and Campbell 1327. Yield observations were made on 30 plants, root observations on 15 plants.

Influence of crop rotations on the root-knot nematode infestation and yield of tomatoes

An experiment (split-plot design with 3 replications) was installed on a *M. incognita* infested field of the Station d'Appui Medjerda. The influence of the introduction of a cereal into a cropping pattern was examined. Therefore 3 crop sequences were examined (see table 2). The plots (154 m²) receiving tomatoes were planted partially with a root-knot susceptible (Super Roma VF) and a root-knot resistant cultivar (Roma VFN) during the months March or April. Local varieties were used for wheat and cucumber.

Wheat was sown during the November month, cucumber during April. The tomato crop was preceeded each time by a *Vicia faba* var. *minor* crop which was ploughed in.

Chemical soil disinfestation

The experiment was conducted at Douar El Bey on a private farm infested with M. *incognita*. Four treatments were compared with a control : (a) dichloropropene - dichloropropane, 300 l/ha applied 1 month before transplanting by a PAL injectorgun at a soil depth of 15 to 18 cm in a grid spacing 20 x 20 cm. (b) carbofuran 10 kg/ha applied and incorporated into the soil on the planting row 4 days before transplanting (c) phenamiphos 10 kg/ha broadcast and incorporated into the soil 4 days before transplanting. (d) dibromochloropropane 11.4 l/ha distributied in the irrigation water 14 days after transplanting. All plots (2,4 x 2 m) were planted on 12 April with 10 Roma VF plants. Plants used in above mentioned experiments were 5-6 weeks old and raised in DD-treated beds. The plots were individually furrow irrigated and fertilizers were applied by the farmers following the rules of good agricultural practice. Harvest of red coloured fruits was done weekly until mid-september. At the end of the experiments the plants were dug from the plots and their roots were graded for the degree of galling on a scale 0 to 10, with 0 representing no galling and 10 destruction of the root system (6). Comparing the degree of infection of treated with non treated plants a degree of efficiency, expressed in percent of the reference plants, has been determined according to the same author.

For better understanding yield data have been expressed in percent of the maximum observation or the control. Data were analysed by the method of the least significant difference.

TABLE 1

Yields and root-knot infection of selected tomato cultivars in soil infested with *M. incognita* (expressed in percent of the maximum observation).

Cultivar	Total yield	Number fruits per plant	Mean fruit Weight	Degree of efficiency on tomatoes planted at			
				17.04	05.05	26.05	12.06
Roma VFN	100.00 a (1)	100.00 a	52.14 b	100	100	100	100
Roma VF	73.63 b	80.32 b	44.92 b	0	6	20	45
Piersol	55.82 b	28.84 c	100.00 a	100	100	100	100
St Pierre	43.03 c	22.23 c	94.38 a	0	4	15	70

(1) Within columns, values followed by the same letter are not significantly different according to LSD test (P = 0.05).

Results and discussion

Influence of date of planting and cultivar

Table 1 summarizes the observations made on the yields and root-knot infection obtained at the end of the crop. Already early after the first harvest differences in yield between the Roma and Piersol group were remarkable : the first gave an earlier and higher total yield than the latter. For the same type of cultivar the root-knot nematode resistant one gave the highest yield. The introduction of the resistance gene caused an improvement of the yield of about 25% with regard to its susceptible homologue. In the Roma group this is owing to a significant higher number of fruits per plant and also, although not significantly, to a higher mean fruit weight. These differences were not significant between Piersol and St Pierre. The date of transplanting had an important influence on the yield of the tomato. The best yields were obtained with plantings on the first 2 dates. Fruitset is difficult or non existant during the warm summer months; this might be the reason that the differences in yield and number of fruits per plant between root-knot resistant and susceptible cultivars were only found for the first 2 dates of planting for the Roma and at the first planting day for the Piersol group.

Highest root-knot infection has been found on the roots of St Pierre planted on 17 April. Roma VFN and Piersol kept their root-knot resistance properties during the whole season and showed a degree of efficiency of 100%. The age of the tomato plant at the time of root-knot nematode invasion did not appear to influence resistance.

The susceptible cultivars had the highest root-knot index when planted on the first date. For the same planting date there was no difference between the two susceptible cultivars.
Retarding the planting date resulted in lower root-knot infection, increasing the efficiency.

TABLE 2

Yield obtained by a root-knot susceptible (Roma VF) and resistant (Roma VFN) tomato cultivar in different years of 3 cropping sequences on *M. incognita* infested land (in percent of the maximum obtained during a year).

Year of cropping		Yield of the tomato crop in cropping sequence 1			2			3	
		S(2)	R		S	R		S	R
1	To(1)	86	100	To	132	100	Fa	—	—
2	To	123	100	Wh	—	—	To	190	130
3	To	98	100	To	111	116	Wh	—	—
4	To	82	100	Wh	—	—	Cu	—	—
5	To	79	100	To	82	110	To	100	121

(1) Crop grown : To : tomato; Wh : wheat; Cu : cucumber; Fa : fallow.

(2) Cultivar used for tomato crop : S : root-knot susceptible Roma VF; R root-knot resistant Roma VFN.

Resistant tomato cultivars

On root-knot nematode infested land the best yields were obtained with root-knot resistant cultivars. The resistant variety Roma VFN differed significantly from Roma VF at two of three locations.

Its yield differed not significantly from the yield obtained by the best variety in all three locations. A good standard variety as Cal J, was classified in the same group as Roma VF. Root-knot resistant cultivars producing a round shaped fruit with a higher mean fruit weight (e.g. Atkinson, Calmart, Manulcie) did not give the best yield if they were not early. VFN 8, a precousious cultivar, gave at Zahrouni the best yield.

Round schaped fruits are not desired by the fresh tomato consumer during summertime, nor by the canning industry because of the low solids. Our observations did not reveal important differences between the dry matter content and pH value of the juice of the examined cultivars.

Observations made on the level of root-knot infection revealed the complete resistance of the nematode resistant varieties. Others had a variable degree of infection. The F2 hybrid cultivar Slumac was only slightly infected. Most plants of this cultivar showed no galling.

In a second experiment done at Saïda, the root-knot resistant cultivars (Slumac, Roma VFN) gave the highest yields. At mid August they were the only cultivars still alive in the field.

The latest planting date (08.05) gave a lower index (minus one cycle of the nematode) than the first one (15.04). The index of the F2 hybrid cultivar Slumac (2.2 to 2.8) gave a good image of its resistant characteristics (25% susceptible and 75% resistant plants).

Cropping patterns

Table 2 summarizes the yields obtained for the tomato crop during the different years. They are expressed in percentage with regard to the yield obtained by the root-knot resistant cultivar in cropping pattern number 1. As climatic conditions and cropping practices might differ, comparison between the different years must be made with caution. Only after the third year of the experiment were yield differences between the resistant and susceptible cultivars in favor of the resistant variety. Continuous cropping of a susceptible tomato cultivar resulted in a yield reduction of about 21 percent after 5 years. The introduction of wheat in the cropping pattern did not give a significant improvement of the yield of the susceptible cultivar. The cropping pattern in which a tomato crop returned 2 years after a previous one gave the highest yield : this dispite the fact that cucumber was included. At the end of the experiment the resistant cultivar had the best performences within each cropping pattern.

The resistant tomato cultivar never showed root-knot infection. Five year continious cropping of a root-knot resistant tomato cultivar were not sufficient for obtaining resistance breaking biotypes of *Meloidogyne*. Root-knot infection of susceptible tomatoes at the end of the cropping sequences decreased with increasing interval between 2 tomato crops. The root-knot index observed after cropping sequences 1 and 2 was 7 and 6,5 respectively. Tomatoes in the third cropping sequence showed only a root-knot index of 4,3. Yields and root-knot nematode infection obtained during the 5th year in the second cropping pattern prove that wheat was without effect on the root-knot population. Wheat however was grown in for root-knot nematodes less optimal climatic conditions, only the latest quarter of the cropping time took place at higher temperatures. The beneficial influence of the third cropping sequence, containing wheat and cucurbits is remarkable. The difference between the root-knot susceptible and resistant cultivar was nevertheless reduced, probably on account of the cucumber crop preceeding the second crop.

TABLE 3

Influence of nematicidal treatments on the yield of a susceptible tomato cv. and on the degree of efficacity obtained at the end of the crop.

Nematicide	Yields Early (1) yield	Total yield	Fruit number	Degree of efficiency
DD	159 a (2)	126 a	135 a	14.7
Carbofuran	114 bc	89 bc	100 ab	13.4
Phenamiphos	138 ab	119 ab	120 a	75.4
DBCP	111 c	67 c	69 b	30.5
Control	100 c	100 abc	100 ab	0

(1) Early yield = yield obtained 1 month after first harvest.

(2) Within columns, values followed by the same letter are not significantly different according to LSD lest (P = 0.05).

Chemical soil desinfestation

The irrigation with dibromochloropropane at 11.4 l/ha as recommanded by Decker (1) was phytotoxic to the young tomato plants and reduced significantly their survival (32% losses).

All the tested nematicides, excepted DBCP, improved the early yield (yield obtained 1 month after first harvest) (table 3).

However only the yields obtained after the phenamiphos and DD treatments were significantly different from those obtained on the control plots. The same nematicides gave also the best total yields, although not significantly different from the control. This higher yield was done to higher fruit number. The reduction in the number of tomato plants, caused by the DBCP treatment, was reflected in reduced yield.

The influence of nematicide treatments on the root-knot index was more pronounced. The highest degree of efficacity was obtained by the phenamiphos overall treatment. The carbofuran application on the planting row gave only a limited protection as did the DBCP and DD treatments. The time at which the treatments with the fumigants were executed was not optimal.

Conclusion

All the experiments proved the superiority of the root-knot resistant cultivars in root-knot nematode infested land. In the experiments resistance has never been broken by resistance breaking pathotypes. Root-knot nematode densities are not high, so that the recommendations formulated by Netscher (4) on the use of non-hosts and resistant varieties in slightly infested or non-infested land can be applied.

The date of transplanting had its influence on the crop. Retarding the transplanting resulted in lower yields. The root-knot resistant cultivars remained resistant at different planting dates.

A cropping pattern where wheat is alternated with tomatoes is not sufficient for reducing the root-knot nematode population to a level permitting the cropping of a susceptible tomato cultivar. More years of cereals are probably necessary to obtain the same results as those obtained by Di Muro (3) and Sundaresh et al. (5). Less frequent return of a tomato crop, as practised in the third cropping pattern, reduces the root-knot nematode population and improves the yield of the tomato crop.

Chemical soil desinfestation improves early and final yield of a tomato crop. As summer tomato crops don't pay very well, judicious use of a root-knot resistant cultivar might be the best solution for the root-knot problem. If conventional soil disinfestation has to be practised, although too expensive and disrupting the biological equilibrium of the soil, the best moment for the treatment might be at the end of the summer and before a winter crop. At that moment the free second stage juveniles are numerous and soil temperature and conditions are optimal. During winter, low temperatures do not permit the multiplication of root-knot nematodes on susceptible crops.

Bibliography

1. Decker, H., 1969. Phytonematologie. VEB-Deutch. Landw. Verlag-Berlin, 526 pp.
2. Lamberti, F., 1979. Economic importance of *Meloidogyne* spp. in subtropical and mediterranean climates. pp. 341-357. *In* F. Lamberti and C.E. Taylor (Editors). Root-knot neamtodes (*Meloidogyne* spp.) Systematics, Biology and Control. Academic Press, London, New York.
3. Muro, A. Di, 1975. Root-knot nematode (*Meloidogyne incognita*) control by two and three year crop rotations. Ann. Ist. Sper. Tabacco, **2**, 89-91
4. Netscher, C., 1978. Morphological and physiological variability of species of *Meloidogyne* in West-Africa and implications for their control. Meded. Landbouwh. Wageningen, 78, 46 pp.
5. Sundaresh, H.N., Setty K.G.H. and Govindu, H.C., 1977, Integrated control of root-knot nematode (*Meloidogyne incognita* Chitwood). Mysore J. of Agric. Sci., **11**, 540-543.
6. Zeck, W., 1971. Un schéma de notation pour l'évaluation des infestations de nématodes cécidogènes en plein champ. Pflanz.- Nachr., **24**, 145-148.

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