STUDIES ON NEMATODES OF FOOD LEGUMES

PROGRESS REPORT
1984/85

FOOD LEGUMES IMPROVEMENT PROGRAM

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Preface

Research on the nematodes of chickpea, lentil and to a lesser extent faba bean, have continued in 1984/85 in cooperation with the Istituto di Nematologia Agraria, C.N.R., Bari, Italy. The aim of the investigations reported herein was to focus on biology, host ranges and control of the most important nematodes of pulses in Syria, their distribution, crop loss assessment, and screening of chickpea and lentil lines for resistance to the above nematodes. The researches were conducted in Syria and in Italy by Dr. M.V.Reddy, Dr. R.S.Malhotra, Dr. M.C.Saxena, Dr. W. Erskine and Mr. S. Hajjar of ICARDA and Dr. N. Greco and Dr. M. Di Vitto of Bari (Italy).

1. SUMMARY

1.1 In Syria, the three major nematodes affecting chickpea are cyst (Heterodera sp.), root-knot (Meloidogyne artiellia) and root-lesion (Pratylenchus thornei) nematodes. Cyst nematode is more widespread and hence more damaging than root-knot nematode on spring-sown chickpeas. Lentil yields are reduced by infestation with Heterodera sp. in Syria.

1.2 Host range studies have shown that M.artiellia reproduces very well on Leguminosae, Cruciferae and Graminaceae. Most of the species belonging to Solanaceae, Umbelliferae, Chenopodiaceae, Cucurbitaceae and Malvaceae were poor or non-host of the nematode. All members of Compositae, Liliaceae, Linaceae and Rosaceae were non-host. It has been confirmed that Heterodera sp., instead, reproduces well on several Leguminosae, such as chickpea, lentil and pea, and only a few females were observed on carnation. Wild species of chickpea also were good hosts for cyst nematode (Heterodera sp.).

1.3 Heterodera sp. can complete its life cycle in about 40 days at 20°C and second stage juveniles emerge easily from cysts at 15-25°C. Solutions of 3 mM zinc chloride gave good egg hatch.

1.4 A pot culture technique was utilized to screen for resistance to cyst nematode in chickpeas and lentils in the green house in Syria, and in Italy. Preliminary screening of 253 chickpea lines indicated large genotypic differences for susceptibility and advanced screening showed good tolerance in 11 lines. In lentils a total of 175 lines were screened and, although genetic differences in susceptibility were found, there was no resistance.

1.5 Screening of 341 lines of chickpea for resistance to root-knot nematode in Italy revealed no genetic variation.

1.6 In an experiment on the relationship between cyst nematode infestation rates and crop damage (lentils and chickpeas), it was found that at 32 eggs/cm^3 soil chickpeas were damaged and yields reduced. At higher rates the plants were nearly all killed. In lentils symptoms appeared at infestation rates of 32 eggs/cm^3 soil, but the plants were not killed.

1.7 Soil application of Aldicarb (Temik) reduced nematode populations of root-lesion nematode and root necrosis.

2. INTRODUCTION

Research on nematodes started during 1982-83 in collaboration with the Istituto di Nematologia Agraria, C.N.R; Bari, Italy, after observations of the incidence of root-knot nematode in some of the chickpea experimental plots. Initially there was emphasis on surveys to determine the distribution and damage of nematodes, identification of the important nematode species affecting the crop and standardisation of screening techniques for identifying host-plant resistance.

3. SURVEYS

Surveys were conducted during 1982-83 and 1983-84. Soil and plant samples were collected mostly from chickpea fields, and also from lentil, faba bean, alfalfa, and vetch from northern Syria, also additional samples were collected from the southern and central parts of Syria. The samples were analysed but the cyst nematode (Heterodera sp.) again was found to be very widespread and destructive in some fields.

While root-knot (Meloidogyne artiellia) and root-lesion (Pratylenchus thorneii) nematodes seem to be sporadic on winter-sown chickpeas, cyst nematode is more common on the spring-sown chickpeas and is also widely prevalent in the farmer's fields, especially on the road of Idleb-Saraqeb, which was surveyed again during 1984-85 and showed much damage.

4. HOST RANGE

4.1 Host range of Meloidogyne artiellia.

The root-knot nematode, Meloidogyne artiellia, has been reported to cause yield losses of chickpea in Spain, Italy and Syria. Chemical control of the nematode is not feasible because of the low benefit of the crop and high cost of the treatments, but crop rotation could provide an easy and cheap way to limit yield loss of chickpea. Unfortunately, information on the host range of the nematode, required for suggesting appropriate rotations, is scanty. Therefore an investigation was undertaken

in greenhouse at Bari (Italy) to assess the host status of 53 plant species belonging to 12 botanical families and of economic importance in the Mediterranean area. The plants were grown in clay pots containing 750cm^3 of soil. When the plants had germinated, each pot was inoculated with 20,000 eggs and juveniles of the nematode. Forty-five days later the plants were lifted and the nematodes in 5 g of roots extracted and counted. Numbers of M.artiellia collected from the roots showed that all Cruciferae tested and members of the Leguminosae and Graminaceae were good hosts of the nematode. Most of the members of Solanaceae, Umbelliferae, Chenopodiaceae, Cucurbitaceae and Malvaceae were, instead, poor or non-host. Finally, species of Compositae, Liliaceae, Linaceae and Rosaceae were non-host. Among the Leguminosae and Graminaceae, cowpea, lupin and corn were non host, and bean, lentil, soybean, sanfoin and oat were poor hosts of the nematode and could be included with profit in a rotation programme aiming to limit yield losses caused by M.artiellia. Although most of the non host and poor host plants are cultivated on limited lands, some of them, such as lentil, oat, sunflower, sugarbeet, cotton and flax, are grown on large areas in many Mediterranean countries.

4.2 Host range of the chickpea cyst nematode (Heterodera sp.)

In Syria chickpea has been reported to be badly damaged by a species of cyst forming nematode, Heterodera sp., whose host range was not known. Research on the host range of Heterodera sp. was conducted in both Italy and Syria.

Therefore 50 plant species, most of them tested for their host status toward M.artiellia, were also tested for their susceptibility to the chickpea cyst nematode in Bari, Italy. Several plant species were included to achieve additional information for the identification of this cyst-forming nematode, which is being done at Bari. Experimental conditions were as for M.artiellia, but the pots were inoculated with 15,000 eggs of the nematode/pot before sowing or transplanting, and the nematode extracted from the root two months later. The results confirmed that the host range of the nematode is confined to members of the Leguminosae family and only a few females were collected from roots of carnation, reported to be good host of some populations of H.trifolii,

occurring in Mediterranean countries. All Trifolium sp. tested were found not to be host of the nematode, but large numbers of nematodes were collected from roots of chickpea, lentil and pea. Good host were also cowpea and grasspea. Faba bean, Medicago spp., lupin and vetch were poor hosts. No nematode reproduction was observed on Rumex crispus, the type host of H. rosii. Because of the rather narrow host range of the chickpea cyst nematode, crop rotation, by using non-leguminous crops, should be suggested to avoid yield loss of this nematode.

In Syria species common to the Mediterranean region were retested against cyst nematode to understand its host range. This study was done in artificially infested soil at the rate of 75 cysts/200g soil in the greenhouse. The tested crops comprised food and forage legumes, cereals and others grown in winter, spring and summer seasons. These were: Chickpea, faba bean, lentil, peas, vetch, Medic, Lathyrus, durum wheat, bread wheat, triticale, potato, beet-root, lettuce, turnip, cabbage, cauliflower, radish, carrot, parsley, spinach, coriander, Phaseolus, Vigna, soybean, lupins, maize, sorghum, sunflower, cotton, linseed, tomato, chillies, watermelon, muskmelon, pumpkin, gourds, cucumber, onion, garlic and okra.

The following crops were found to be hosts for cyst nematode:

Entry No.	Crop	No. of cysts/g roots			
		R I	R II	Mean	
1	Peas	476.74	570.95	523.85	Good host
2	Chickpea	435.71	462.56	449.14	
3	Medic	159.6	197.22	178.41	
4	Lathyrus	150.08	196.56	173.32	
5	Lentil	126.48	131.1	128.79	
6	Phaseolus	31.72	84	57.86	
7	Lupins	27.12	44	35.56	
8	Soybean	35.84	18.88	27.36	
9	Vetch	12	16	14	
10	Barley	3.04	9.6	6.32	very poor or non-host
11	Faba bean	5.6	0	2.8	
12	Sunflower	2.56	2.4	2.48	

The other crops showed no infection of cysts, and were non-hosts.

5. BIOLOGY

5.1 Investigations on the biology of the chickpea cyst nematode.

The aim of these studies was to gain information on the life cycle of the nematode as affected by different temperatures and on the hatching of the eggs.

The life cycle of the nematode was investigated at 20°C. Several second stage juveniles of the nematode were observed within the roots of chickpea when the plants were four days old, however gravid females and cysts were observed 22 and 40 days later; and 18 days were required by the eggs to complete their embryogenic development.

The emergence of juveniles from cysts was nearly inhibited at 5 and 30°C, negligible (3.8%) at 10°C and substantial at 15-25°C (15.9 - 31.4%).

Of 15 root leachates tested for their effect on the hatching of the cyst nematode, only that from pea stimulated a remarkable egg hatch, but those from sugarbeet, cauliflower, cotton, chickpea, faba bean, bread wheat, alfalfa, potato, soybean, white clover and vetch, were ineffective. However, root leachate of chickpea had proved to be effective in a previous study. Solution containing 0.6 mM of sodium metavanadate and 0.3 mM of picrolonic acid, stimulated hatching to some extent but less than pea root leachate. The best hatching stimulation was performed by a 3 mM of zinc chloride solution which doubled the numbers of juveniles emerged in the pea root leachate.

6. SCREENING

6.1 Screening of chickpea lines for resistance to M.artiellia in Italy.

Three hundred forty one lines of Cicer arietinum, three of the wild species C.judaicum and C.pinnatifidum, and one line each of C.reticulatum, C.cuneatum and C.bijugum were sown in clay pots of 500m^3 and inoculated with 10,000 eggs of M.artiellia/pot when the seeds had germinated. Each line was replicated 8 times. After two months the plants were uprooted and the roots washed free of adhering soil and shaken for 3 minutes in a 1% sodium hypochlorite solution to release eggs from egg masses, and evaluate the reproduction of the nematode.

Even though some differences were observed on the reproduction of M.artiellia on lines of C.arietinum, none were resistant to the nematode. All wild species of Cicer were highly susceptible to the root-knot nematode.

6.2 Screening of chickpea lines for resistance to Heterodera sp. in the greenhouse, ICARDA.

Soil was collected from infested fields near the Idleb-Saraqeb road during 1982-83. This year(1985), potswere filled with infested soil of cyst nematode (Heterodera sp.) at the rate of 75 cysts/200g soil. Out of 290 Ascochyta blight resistant, newly-developed, kabuli lines, 27 lines were rated 4 and less (resistant) in the last season. These lines were put in an advanced screening trial consisting of 3 replications, 7 seeds/pot. Out of these, 3 lines showed resistance to cyst nematode they are: FLIP82-215, FLIP83-11 and FLIP83-85 (Table 1). At the same time 183 lines of our newly developed lines (FLIP84) were screened by using augmented design and adding 3 checks in each block, the checks used were ILC 482 (susceptible), ILC 1929 (susceptible) and ILC 3279 (tolerant). Out of these lines 26 were rated 4 and less, and having low number of cysts/g roots. They are: FLIP84-2, 84-7, 84-10, 84-16, 84-19, 84-43, 84-48, 84-61, 84-63, 84-64, 84-67, 84-79, 84-81, 84-102, 84-104, 84-112, 84-121, 84-124, 84-148, 84-156, 84-169, 84-173, 84-174, 84-176, 84-184, 84-188. (Table 2).

These 26 lines plus 3 lines from the previous screening were screened in an advanced trial, out of which we found 11 lines resistant or tolerant to cyst nematode. They are: FLIP83-85, FLIP84-7, FLIP84-43, FLIP84-61, FLIP84-63, FLIP84-67, FLIP84-81, FLIP84-104, FLIP84-112, FLIP84-124 and FLIP84-188. (Table 3).

In addition to this, 70 lines from our crossing program 1984-85 were screened in an augmented design and resulted in 7 tolerant lines to cyst nematode. They are: ILC 136, ILC 470, ILC 1919, ILC 2506, ILC 4295, FLIP82-91 and FLIP83-15. These lines will be retested in the season. Another screening of our wild species of chickpea was done by using different species, out of 9 lines only one was tolerant NEWC 7 (Cicer bijuqum). (Table 4).

6.3 Screening of lentils for resistance to Heterodera sp.

This work was conducted in two components. Firstly, lentil germplasm accessions were screened for their reaction to a Syrian population of chickpea cyst nematode at Bari in Italy; and, secondly, lentil elite lines from the crossing block were screened for their reaction to the same cyst nematode at Tel Hadya, Syria.

The germplasm comprised 100 accessions of lentil from a total of fifteen countries and also one accession of L.orientalis. Lentil seeds were sown in 100cm^3 plastic cups containing soil infested with 2,000 eggs of the nematode/cup. All developmental stages of the nematode were extracted from the roots of each of the 12 plants/line after two months.

There were significant differences between the accessions in susceptibility with a range of 169 to 1937 nematodes found per 5g roots (Table 5). The wild lentil accession was also susceptible to the cyst nematode. None of the material exhibited a resistant reaction to the nematode.

A total of 75 lentil elite lines were screened for reaction to cyst nematode in the plastic house at Tel Hadya, Syria. Five seeds were sown per plastic pots in soil derived from a local infested site with c.75-80 cysts/200g of soil. The roots were examined after 1½ months of sowing when nematode damage symptoms were apparent. The accessions were rated for damage symptoms and a count of cyst numbers per g root was made. The extreme lines for susceptibility and resistance were selected for rescreening in a replicated trial in the same plastic house.

In the rescreening only 24 lines were tested, including the wild lentil, in two replicates in plastic pots sown with 15 seeds/pot with soil carrying a larger number of cysts (300-350 cysts/200g soil). Measurements of vegetative damage (by an index), total root weight and the number of cysts/g of root were made (Table 6). There were significant differences between the lines for vegetative score and root weight. But there were no significant differences between the entries in the cyst count/g root.

In summary, although there may be differences in susceptibility to cyst nematode in lentils, no resistance has been found after screening 175 lentil entries.

6.4 Screening of chickpea lines for resistance to root-lesion nematode.

Twenty lines of chickpea resistant to Ascochyta blight consisting of kabuli and desi germplasm were choosen from 100 lines earlier screened for resistance to root lesion nematode in an infested soil by the rate of 10-150 nematodes in 500cm3 soil. Each line was sown in 2 rows, 2m length, replicated 4 times. Sowing time was in winter 22 November, 1984.

The lines were highly damaged by frost and no differences were observed for the extent of root necrosis between the genotypes. (Ratings of the roots between 7-9). This table shows the yield(kg/ha)and the damage caused by frost.

Entry No.	Entry Name	RI	RII	RIII	RIV	Mean	Rating of frost damage*
1	ILC 620	-	-	-	-	-	8
2	ILC 3279	600	844	1200	1178	956	6
3	FLIP82-68	1833	1556	1778	2167	1834	5
4	FLIP81-41	-	-	-	-	-	8
5	ICC 641	556	533	389	889	592	6
6	ICC 6989	722	978	189	1111	750	7
7	ICC 12023	489	922	-	-	353	8
8	Sel 80Tr 50004	500	1411	300	1411	906	7
9	ILC 482	-	-	611	500	278	8
10	ICC 9501	611	-	-	-	153	8
11	CAM 67	1389	1478	833	1733	1358	4
12	CAM 68	1333	2167	644	2000	1536	4
13	ILC 1929	889	1333	222	1333	944	7
14	CAM 96	1289	1722	1444	1733	1547	4
15	FLIP81-269	-	667	-	689	339	8
16	CAM 94	1411	1411	1022	1556	1350	4
17	ILC 182	1222	1078	689	889	970	6
18	ILC 183	911	1467	611	1022	1003	6
19	ILC 629	-	-	-	-	-	8
20	FLIP82-236	-	467	389	-	214	8

* 1 = free, 9 = completely killed.

7. Effect of cyst nematode on chickpea lines ILC 482 and ILC 1929.

Fifteen pots of infested soil at the rate of 75 cysts/200g soil were sown by ILC 482, 15 other pots by ILC 1929 on 23/11/1984. Ratings are given on the vegetative parts as follows:

Serial Number	2/1/1985		10/1/1985		17/1/1985		24/1/1985	
	ILC 482	ILC 1929	ILC 482	ILC 1929	ILC 482	ILC 1929	ILC 482	ILC 1929
1	2	2	4	3	8	5	9	8
2	2	2	4	3	8	5	9	8
3	2	1	6	2	8	5	9	8
4	2	1	4	2	7	5	8	7
5	2	2	2	3	7	6	8	8
6	1	1	5	2	8	5	8	8
7	1	1	3	2	7	6	8	8
8	1	1	4	2	8	6	9	8
9	1	1	2	2	8	6	9	8
10	2	1	3	2	8	5	9	8
11	1	1	2	2	6	4	8	7
12	1	2	4	2	7	7	8	9
13	1	1	2	2	6	4	8	7
14	1	1	2	1	7	5	9	8
15	1	2	2	2	7	5	9	8

Three samples from each line were taken, uprooted to extract the cysts from the tissues and to count the cysts.

No. of cysts/g roots in ILC 482 and ILC 1929.

	Rep I	Rep II	Rep III	Mean
ILC 482	378	633.58	617.12	541.22
ILC 1929	354.2	541.72	511.92	486.23

At the time of spring planting three samples of soil from each variety were taken for cyst counting.

No. of cysts/200 g soil in ILC 482 and ILC 1929 (17/3/1985).

	Rep I	Rep II	Rep III	Mean
ILC 482	162	200	189	183.66
ILC 1929	497	525	506	509.33

The number of cysts in the soil containing ILC 1929 is a great deal larger than ILC 482 because the roots of ILC 1929 are growing more than the roots of ILC 482; this helps to increase the population of nematodes before the plants are killed, causing high infestation in the fields.

In late spring three other samples of soil were taken from each line and the number of cysts showed a slight decrease because of the absence of the host which was completely killed three months previously.

No. of cysts/200g soil in ILC 482 and ILC 1929 (21/5/1985).

	Rep I	Rep II	Rep III	Mean
ILC 482	183	175	170	176
ILC 1929	364	478	402	414.66

8. Relationship between population density of Heterodera sp. and yield of chickpea and lentil.

The aim of this study was to assess yield losses caused by Heterodera sp. on chickpea (var. ILC 482 (winter + spring)) and lentil (ILL 4401).

This experiment was conducted outside the greenhouse, at Tel Hadya (Syria). Inoculum of eggs of cyst nematode is prepared and mixed with sterilized soil in 12 treatments replicated 9 times in 6 dm^3 pots:

Tr_1 = Control (without inoculum)
Tr_2 = 0.125 eggs/cm^3
Tr_3 = 0.25 eggs/cm^3
Tr_4 = 0.5 eggs/cm^3
Tr_5 = 1 eggs/cm^3
Tr_6 = 2 eggs/cm^3
Tr_7 = 4 eggs/cm^3
Tr_8 = 8 eggs/cm^3
Tr_9 = 16 eggs/cm3
Tr_{10}= 32 eggs/cm^3
Tr_{11}= 64 eggs/cm^3
Tr_{12}= 128 eggs/cm^3

In general symptoms of nematode damage appeared in treatments 8, 9 and 10 but 11 and 12 were completely killed in winter and spring chickpea. However winter chickpea was severely damaged by frost.

Nematode symptoms on lentil appeared in treatments 10, 11 and 12. Treatment 1 did not grow, probably because of the need of Rhizobium in the sterilized soil under the conditions of Tel Hadya.

The tables 7, 8 and 9 show the biological and grain yield of winter and spring chickpea and lentil. For cyst counting, the soil samples were sent to the Istituto di Nematologia Agraria in Bari, Italy.

Future work should be done in a larger volume of soil per pot.

9. Estimation of yield loss due to root-lesion nematode at ICARDA (Syria).

A field experiment was conducted in an infested plot by applying Aldicarb (Temik) at different doses and times to determine the extent of yield loss due to the root lesion nematode and to obtain information on the proper dose and time of application of the nematicide for control. The infestation varied between 35-200 larvae/500cm^3 soil. The experiment was conducted on 3 crops: Chickpea (ILC 482) winter + spring, faba bean (ILB 1814) and lentil (ILL 4400); it included 6 treatments, replicated 6 times in randomized complete block design. The treatments were as follows:

Tr_1 = 5kg/1000m^2 (Aldicarb) before sowing
2.5kg/1000m^2 (Aldicarb) after germination
2.5kg/1000m^2 (Aldicarb) preflowering stage.

Tr_2 = 5kg/1000m^2 (Aldicarb) before sowing
5kg/1000m^2 (Aldicarb) after germination

Tr_3 = 10kg/1000m^2 (Aldicarb) before sowing

Tr_4 = Seed treatment 3g/kg (Aldicarb)
2.5 kg/1000m^2 (Aldicarb) after germination
2.5 kg/1000m^2 (Aldicarb) preflowering stage

Tr_5 = Seed treatment 3g/kg (Aldicarb)

Tr_6 = No application

Winter chickpea was completely destroyed because of the frost.
The other crops were highly infested and also damaged by Orobanche.

Observations on extent of root necrosis, number of nematodes/g roots were recorded.

Effect of Aldicarb on the number of larvae/g roots on faba bean.

Treatments	Rep I	Rep II	Rep III	Rep IV	Rep V	Rep VI	Mean	
Tr_1	0	0	1	0	1	4	1	
Tr_2	0	0	1	2	1	0	0.67	
Tr_3	0	0	3	2	0	1	1	
Tr_4	2	0	2	1	0	4	1.5	
Tr_5	16	17	17	4	19	31	17.3	Seed treatment
Tr_6	36	22	13	23	25	43	27	No application

All the roots were black.

This table shows the good relation between the application of Aldicarb and the control of root-lesion nematode on faba bean.

Lentil was free from larvae of root-lesion nematode and yield(kg/ha)was recorded as follows:

Yield of lentil(kg/ha)in the different treatments

Treatments	Rep I	Rep II	Rep III	Rep IV	Rep V	Rep VI	Mean
Tr_1	583	833	1178	444	611	1489	856
Tr_2	639	433	1705	683	694	1528	947
Tr_3	917	1400	583	517	778	1472	945
Tr_4	517	1583	511	778	761	944	849
Tr_5	378	528	444	650	639	833	579
Tr_6	222	1567	1239	667	683	655	839

This shows Tr_5, Tr_6 having less yield and the best yield in Tr_2, Tr_3 with application of temik 5 + 5 kg/1000m^2 and 10 kg/1000m^2 respectively.

On spring sown chickpea, observations on extent of root necrosis, number of larvae of root-lesion nematode/g roots and yield kg/ha were recorded as follows:

Ratings on root necrosis of spring sown chickpea 1985

Treatments	Rep I	Rep II	Rep III	Rep IV	Rep V	Rep VI	Mean
Tr_1	5	4	4	4	5	3	4
Tr_2	4	4	4	4	5	5	4
Tr_3	3	4	4	4	5	4	4
Tr_4	7	6	6	8	7	8	7
Tr_5	7	6	7	7	7	8	7
Tr_6	8	6	6	7	7	7	7

Number of larvae/g roots on spring sown chickpea 1985.

Treatments	Rep I	Rep II	Rep III	Rep IV	Rep V	Rep VI	Mean
Tr_1	1	0	0	1	0	0	0.33
Tr_2	0	0	0	0	0	0	0
Tr_3	0	0	0	0	0	0	0
Tr_4	5	0	9	0	6	0	3.33
Tr_5	3	3	0	7	26	6	7.5
Tr_6	4	0	0	5	24	27	10

Yield(kg/ha)of spring sown chickpea 1985.

Treatments	Rep I	Rep II	Rep III	Rep IV	Rep V	Rep VI	Mean
Tr_1	1572	1455	1639	1139	1811	2455	1679
Tr_2	1405	1428	1761	1333	1178	2794	1650
Tr_3	1294	1944	1844	1417	1594	1878	1662
Tr_4	650	1733	1611	1489	1483	905	1312
Tr_5	1267	861	1239	1028	1205	1389	1165
Tr_6	1572	1211	1067	1428	1194	850	1220

From these tables it is observed that the best treatments for yield are Tr1, Tr2, Tr3. Tr_4 with a low dose of Aldicarb + Seed Treatment, Tr_5 with only seed treatment and Tr_6 without application of Aldicarb gave lower yields, and the root necrosis and the number of larvae were higher in these treatments.

In conclusion, although trends were observed in this season's trial the effects of frost damage and Orobanche mitigated against clear results. The trial will be repeated next season.

18 September, 1985
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Table 1. Advanced screening of 27 lines of chickpea for cyst nematode.

Entry Number	Entry Name	Rating	No. of cysts/g roots	
1	ILC 196	7	220	
2	ILC 197	7	247	
3	ILC 446	6	205	
4	ICC 6306	7	562	
5	FLIP82-20	7	209	
6	FLIP82-40	7	546	
7	FLIP82-118	5	182	
8	FLIP82-129	5	283	
9	FLIP82-144	4	128	
10	FLIP82-167	7	155	
11	FLIP82-191	6	423	
12	FLIP82-197	5	170	
13	FLIP82-215	3	99	*
14	FLIP82-221	7	338	
15	FLIP82-245	7	226	
16	FLIP83-7	5	183	
17	FLIP83-8	5	166	
18	FLIP83-11	3	34	*
19	FLIP83-29	6	278	
20	FLIP83-32	8	101	
21	FLIP83-36	9	397	
22	FLIP83-65	7	209	
23	FLIP83-74	8	196	
24	FLIP83-78	8	125	
25	FLIP83-82	7	350	
26	FLIP83-85	4	74	*
27	FLIP83-91	6	256	
28	FLIP82-236 (check)	7	214	

Table 2. 26 lines of chickpea screened for cyst nematode out of 183 lines.

Entry Number	Entry Name	Rating	No. of cysts/g roots
1	FLIP84-2	3	66
2	FLIP84-7	3	27
3	FLIP84-10	3	78
4	FLIP84-16	3	60
5	FLIP84-19	3	11
6	FLIP84-43	3	108
7	FLIP84-48	2	114
8	FLIP84-61	2	105
9	FLIP84-63	2	34
10	FLIP84-64	3	77
11	FLIP84-67	3	84
12	FLIP84-79	2	102
13	FLIP84-81	2	96
14	FLIP84-102	2	117
15	FLIP84-104	4	46
16	FLIP84-112	2	199
17	FLIP84-121	2	116
18	FLIP84-124	3	93
19	FLIP84-148	4	81
20	FLIP84-156	2	52
21	FLIP84-169	3	70
22	FLIP84-173	3	105
23	FLIP84-174	2	47
24	FLIP84-176	2	139
25	FLIP84-184	2	53
26	FLIP84-188	1	13

Table 3. Advanced screening of 29 lines of chickpea

Entry Number	Entry Name	RATINGS				
		Rep I	Rep II	Rep III	Mean	
1	FLIP82-215	5	5	5	5	
2	FLIP83-11	3	4	4	4	
3	FLIP83-85	3	3	4	3	*
4	FLIP84 2	6	5	4	5	
5	FLIP84-7	3	3	3	3	*
6	FLIP84-10	-	-	-	-	No. germination
7	FLIP84-16	-	-	-	-	"
8	FLIP84-19	-	-	-	-	"
9	FLIP84-43	3	4	3	3	*
10	FLIP84-48	4	4	4	4	
11	FLIP84-61	3	3	3	3	*
12	FLIP84-63	3	3	4	3	*
13	FLIP84-64	4	4	4	4	
14	FLIP84-67	4	3	3	3	*
15	FLIP84-79	4	4	3	4	
16	FLIP84-81	3	3	4	3	*
17	FLIP84-102	4	3	4	4	
18	FLIP84-104	3	3	4	3	*
19	FLIP84-112	3	3	3	3	*
20	FLIP84-121	4	5	5	5	
21	FLIP84-124	3	4	3	3	*
22	FLIP84-148	3	4	4	4	
23	FLIP84-156	5	5	4	5	
24	FLIP84-169	7	5	7	6	
25	FLIP84-173	5	5	7	6	
26	FLIP84-174	7	7	7	7	
27	FLIP84-176	4	3	4	4	
28	FLIP84-184	7	5	4	5	
29	FLIP84-188	4	3	3	3	*
30	ILC 482	8	8	8	8	
31	ILC 1929	7	7	8	7	
32	ILC 3279	6	7	6	6	

* Rating of 3.

Table 4. Screening wild species of chickpea for cyst nematode.

Entry No.	Entry Name	Species	Rating	Root weight	No. of cysts/ gram roots
1	NEWC 4	Cicer judaicum	2	3.6	455
2	NEWC 7	Cicer bijugum	2	5	91*
3	NEWC 9	Cicer pinnatifidum	5	1.73	228
4	NEWC 16	Cicer chorassanisum	7	0.06	1440
5	NEWC 19	Cicer cuneatum	3	3.64	529
6	NEWC 20	Cicer judaicum	2	5	576
7	NEWC 21	Cicer reticulatum	2	5	289
8	NEWC 22	Cicer pinnatifidum	5	2.82	590
9	NEWC 29	Cicer pinnatifidum	2	5	675
10	NEWC 30	Cicer judaicum	2	4.9	838
11	ILC 482 (check)	Cicer arietinum	5	4.11	798
12	ILC 1929 (check)	Cicer arietinum	4	5	575

Table 5. Number of nematodes found in the roots of lentil lines inoculated with a Syrian population of Heterodera sp.

Accession	Country of origin	Nematode numbers found in the roots	
		in 5 g roots	/root system plant
ILL 1	Jordan	228.4	50
ILL 2	"	468.2	200
ILL 3	"	598.7	105.4
ILL 6	"	488.6	98.9
ILL 7	"	323.5	80
ILL 8	"	1045.6	227.4
ILL 9	"	667.3	144.1
ILL 12	"	633.7	124.8
ILL 13	"	1431.8	165.4
ILL 14	"	477.7	81.6
ILL 15	"	431.6	97.4
ILL 16	"	817.9	145.7
ILL 17	"	461.1	104
ILL 18	"	391.7	87.4
ILL 19	"	254.5	75.2
ILL 20	"	407.1	158.7
ILL 23	"	279.1	94.6
ILL 24	Syria	887.6	171.3
ILL 25	"	496.5	150.4
ILL 26	"	575.1	256.4
ILL 27	"	877.8	249.4
ILL 28	"	1019.9	376
ILL 29	"	971.5	288
ILL 30	"	1061.8	452
ILL 31	"	871.3	230.2
ILL 32	"	260.2	60
ILL 33	"	435.4	165.4
ILL 34	"	965.5	273.9
ILL 35	"	1113	225.2
ILL 36	"	894.8	250.5
ILL 37	"	904.7	275.4

...Cont'd 2/

Accession	Country of origin	Nematode numbers found in the roots	
		In 5 g roots	/root system plant
ILL 38	Syria	137.5	34.9
ILL 39	Syria	1020.7	300.5
ILL 40	Syria	343.6	63.2
ILL 41	"	537	166.2
ILL 42	"	186.2	31.9
ILL 43	"	587	160.3
ILL 44	"	768.2	265
ILL 46	"	725.2	196
ILL 47	"	225.7	44.1
ILL 48	"	419.3	46.9
ILL 50	"	400.5	125
ILL 49	Iraq	1411.6	125
ILL 51	"	489.7	68.7
ILL 52	"	251.8	49
ILL 53	"	553.8	110.5
ILL 54	"	224.5	70.4
ILL 55	"	717.2	125
ILL 56	"	242.2	87.1
ILL 57	"	569.4	124
ILL 59	"	288.4	81.4
ILL 60	"	228.6	58.2
ILL 61	"	185.8	63.2
ILL 62	"	209.4	51.8
ILL 63	Iran	229.2	79.4
ILL 64	"	317.2	88.7
ILL 65	"	168.7	52.3
ILL 66	"	289.4	81.7
ILL 67	"	636.9	122.4
ILL 72	"	582.3	207.3
ILL 73	"	491.6	168.5
ILL 96	Morocco	631	229.5
ILL 97	"	1937.2	425.8
ILL 98	"	434.2	99.1
ILL 99	"	263.2	60.1

Accession	Country of Origin	Nematode numbers found in the roots	
		In 5 g roots	/root system plant
ILL 100	Morocco	887.9	285.1
ILL 101	Morocco	241	113.3
ILL 71	Turkey	197.1	83.5
ILL 107	Turkey	645.9	161.1
ILL 113	"	444.6	110.9
ILL 114	"	388.7	124.8
ILL 115	"	680.7	242.9
ILL 117	"	400.7	173.9
ILL 118	"	226.6	58.1
ILL 119	"	351.9	135.1
ILL 120	"	641.8	208.1
ILL 121	"	223.6	85.6
ILL 122	"	177.8	62
ILWL7	L.orientalis	260	70
ILL 68	Lebanon	237.7	73.8
ILL 70	"	262.8	102.4
ILL 74	Chile	654.4	139.1
ILL 75	"	741.5	101.1
ILL 76	"	928.6	272.5
ILL 77	"	563.9	83.9
ILL 78	"	562.4	113.1
ILL 82	U.S.S.R.	616.8	158
ILL 84	"	1692.9	364.7
ILL 87	"	924.2	314.5
ILL 92	"	1049.6	224.4
ILL 93	"	1150.7	366.8
ILL 79	Spain	574.9	211.5
ILL 80	"	428.8	167.3
ILL 81	"	571.5	185.3
ILL 69	Cyprus	589.8	116.6
ILL 83	Afghanistan	476.7	93
ILL 102	Greece	268.4	161.5
ILL 103	Greece	668.4	250
ILL 104	Greece	781.1	274
ILL 90	Germany	1074.3	313.1
ILL 105	U.S.A.	498.3	258.4

Table 6. Table of means for screening of lentils for resistance to Heterodera sp.

Entry	Vegetative score	Root Weight (g)	No. cysts/g
ILL 5572	7.7	3.13	323.97
ILL 5584	7	4.5	89.8
ILL 5582 (78S 26002)	7	4.9	65.9
ILL 975	6.3	3.1	119
ILL 2130	6.3	2.57	793.5
ILL 5884	6	1.53	346.7
ILL 5714	5.7	2.97	67.4
ILL 5426	5.3	4.77	67.77
ILL 2602	5	1.8	460.4
ILL 857	5	4.9	338
ILL 5588	5	2.77	71
ILL 468	5	7.2	156.9
ILL 5747	4.7	5.2	45.03
ILL 5698	4.7	5.1	155.7
ILL 5700	4.7	5.6	39
ILL 5753	4.7	3.5	18.5
ILL 5743	4.3	6.77	146.96
ILL 5762	4.3	6.97	29.4
ILL 5732	4	2.57	34
ILL 2126	4	9.2	153.76
ILL 5673	3.7	3.13	96.4
FLIP85-41-L	3.7	7.27	80
ILL 5507	3.7	11.8	131
ILWL 7	2	2.57	54.34
L.S.D. (5%)	1.86	2.89	N.S.*

* Non-significant at $P < 0.05$

Table 7. Biological and grain yield of winter chickpea(gram/pot).

Treatments	R I		R II		R III		R IV		R V		R VI		R VII		R VIII		R IX		Mean	
Tr1	6.22	3.03	6.06	2.56	40.89	23.92	47.37	23.39	4.70	2.03	42.52	20.90	11.52	2.75	9.62	4.90	50.89	29.76	24.42	12.58
Tr2	22.53	12.53	-	-	3.45	1.17	55.58	29.35	52.92	22.09	4.76	0.99	38.20	21.72	18.80	10.76	22.44	12.50	27.34	13.89
Tr3	17.63	9.10	47.65	25.02	71.29	31.58	31.42	17.77	-	-	-	-	18.55	9.58	27.80	15.55	51.77	30.32	38.02	19.85
Tr4	35.95	18.79	-	-	28.80	15.43	49.29	27.41	20.80	12.50	-	-	-	-	7.04	3.55	18.10	10.67	26.66	14.73
Tr5	19.40	10.42	12.0	5.58	52.40	24.71	10.02	3.55	35.60	18.80	25.16	10.93	22.63	10.99	-	-	-	-	25.32	12.14
Tr6	7.78	3.29	42.09	19.08	12.11	3.37	-	-	19.58	9.60	46.28	25.85	22.64	10.15	37.36	22.03	4.55	1.60	24.05	11.87
Tr7	31.74	14.14	52.43	30.03	71.64	33.35	35.16	19.86	37.39	20.74	45.58	21.57	45.75	24.18	9.62	3.99	42.67	25.21	41.33	21.45
Tr8	3.50	1.12	17.94	10.0	35.56	13.10	26.36	15.40	24.49	13.44	-	-	24.38	10.03	5.36	2.03	-	-	19.66	9.30
Tr9	-	-	-	-	-	-	18.32	6.40	-	-	-	-	-	-	-	-	-	-	18.32	6.40
Tr10	28.64	15.40	6.63	2.55	38.16	15.20	14.46	5.41	24.74	12.10	13.49	6.81	5.98	2.56	14.47	7.45	5.32	2.85	16.88	7.82
Tr11	2.97	0.62	-	-	1.88	-	-	-	2.16	0.36	-	-	-	-	-	-	-	-	0.78	0.10
Tr12	2.67	0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	0.10

Table 8. Biological and grain yield of spring chickpea (gram/pot).

Treatments	R I		R II		R III		R IV		R V		R VI		R VII		R VIII		R IX		Mean	
Tr1	11.67	6.35	42.63	26.77	36.82	19.54	10.88	3.35	14.57	7.31	11.42	2.64	21.33	9.42	6.0	0.91	30.72	18.84	20.67	10.57
Tr2	20.0	8.45	16.45	8.20	59.67	28.36	16.25	9.25	11.34	3.84	4.42	0.90	4.20	-	24.25	13.61	5.57	1.42	18.02	8.23
Tr3	17.36	5.43	18.90	8.85	9.64	2.97	33.54	13.0	9.13	1.45	16.18	2.60	3.69	-	18.22	11.55	11.40	5.64	15.34	5.72
Tr4	15.46	6.12	48.14	19.78	21.93	13.73	6.84	0.91	9.50	2.0	8.42	2.52	29.28	17.18	8.15	3.28	21.49	11.44	18.80	8.55
Tr5	10.44	3.63	27.88	17.30	36.10	21.75	46.90	22.25	6.24	0.78	3.38	-	22.36	12.76	29.28	18.0	9.80	5.35	21.38	11.31
Tr6	10.75	4.20	67.06	40.90	11.60	2.17	12.29	6.04	3.02	-	21.47	7.12	3.97	-	15.76	8.62	3.0	1.0	16.55	7.78
Tr7	17.90	6.23	45.10	13.80	54.18	31.02	17.50	9.16	11.67	2.91	8.44	2.56	10.80	5.55	9.22	0.87	16.69	9.35	21.28	9.05
Tr8	20.32	7.10	31.91	14.32	33.48	14.52	31.80	15.62	7.72	1.84	5.17	1.62	19.28	10.90	2.79	-	8.53	4.91	17.89	7.87
Tr9	34.76	15.32	30.50	12.25	10.56	4.74	6.55	2.12	14.89	3.80	7.61	1.62	20.13	11.55	12.80	7.22	4.66	2.20	15.83	6.76
Tr10	5.89	2.20	6.26	2.24	3.80	-	9.74	3.06	9.53	1.70	7.60	2.31	1.42	-	12.59	8.0	2.48	0.66	6.59	2.24
Tr11	1.84	-	5.04	1.08	4.0	1.15	11.76	5.35	2.64	-	1.22	-	2.70	-	2.33	0.84	1.09	-	3.62	0.94
Tr12	2.0	-	1.45	-	1.64	-	1.90	-	1.72	-	1.47	-	1.73	-	1.75	-	1.06	-	1.64	0.0

Table 9. Biological and grain yield of lentil(gram/pot.) .

Treatments	Rep I		Rep II		Rep III		RIV		RV		RVI		RVII		RVIII		RIX		Mean	
Tr_1	-	-	-	-	1.74	0.10	-	-	-	-	-	-	-	-	1.50	0.32	1.74	0.18	0.55	0.07
Tr_2	16.50	5.34	8.74	2.92	12.74	5.85	7.96	2.59	10.0	2.30	9.75	2.47	18.48	6.50	12.69	4.78	19.86	6.07	12.95	4.31
Tr_3	15.99	6.69	13.44	4.81	18.05	8.07	18.16	8.26	16.69	4.30	13.0	5.32	10.47	4.33	20.54	8.50	19.15	7.19	16.17	6.39
Tr_4	12.0	5.30	21.20	7 95	38.94	18.27	23.39	8.76	12.95	3.93	31.97	12.92	20.0	7.82	24.48	11.70	18.22	6.33	22.57	9.22
Tr_5	26.52	12.40	15.20	4.77	33.94	16.79	31.55	14.92	22.25	10.70	21.62	8.81	19.33	6.84	11.70	4.07	18.26	8.17	22.26	9.72
Tr_6	25.20	10.88	21.70	8.30	28.74	13.07	16.72	6.43	31.77	14.65	35.15	12.26	15.15	5.42	24.15	9.60	11.39	4.33	23.33	9.44
Tr_7	20.85	7.42	20.79	9.65	26.42	10.50	15.56	6.60	24.57	11.20	22.97	8.26	12.29	2.60	14.70	3.95	22.70	11.08	20.09	7.92
Tr_8	24.35	8.25	12.79	4.06	23.30	8.14	19.68	8.38	9.60	3.77	34.0	11.90	6.60	2.70	15.73	6.40	11.50	3.80	17.50	6.41
Tr_9	24.35	11.10	13.36	5.39	13.94	4.90	28.56	12.33	18.64	6.53	25.43	9.15	28.65	11.78	7.80	2.40	17.86	6.44	19.84	7.78
Tr_{10}	17.04	6.82	16.52	5.0	19.60	8.14	26.0	11.16	9.64	2.15	14.46	7.50	17.50	5.78	11.58	4.13	9.80	2.87	15.79	5.95
Tr_{11}	6.16	2.42	5.55	1.32	10.29	3.17	4.80	1.36	3.0	0.93	12.60	6.35	14.0	5.60	5.38	0.60	9.07	4.27	7.87	2.89
Tr_{12}	6.24	1.78	3.65	0.65	7.19	2.25	4.90	1.60	3.69	0.65	10.86	3.36	9.56	3.65	6.70	2.17	5.74	1.82	6.50	1.99