MANAGEMENT OF *HETERODERA CAJANI, MELOIDOGYNE INCOGNITA* AND *FUSARIUM* WILT ON PIGEONPEA WITH SOME CHEMICALS, BIO-PESTICIDES AND BIO-AGENTS

A. Haseeb and P.K. Shukla

Department of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh - 202 002, India

Summary. Experiments carried out for two years (2000 and 2001) at the research farm of the Aligarh Muslim University, Aligarh and in two farmer's fields in the district Bulandshahar (Uttar Pradesh) in northern India indicated that seed treatment of pigeonpea cv. UPAS 120 with dimethoate 30 EC (0.8%), chlorpyriphos (1%), triazophos (3%), neemark/neem jiwan (5%), neem seed powder (5%), spore suspension (10^8 spores/ml) of *Paecilomyces lilacinus*, *Aspergillus niger, Trichoderma harzianum* (1%), latex of *Calotropis procera* (1%) and soil application of neem seed powder (50 kg/ha) and carbofuran (2 kg a.i./ha) in field micro-plots reduced the incidence of *Fusarium* wilt disease of pigeonpea. Severe wilting was observed in untreated plots. Roots of such plants were severely infected with *Fusarium udum, Heterodera cajani* and/or *Meloidogyne incognita*. Wilting of plants at the early stages (25-50 days after sowing) of plant growth was observed. Effects of seed treatments on nematode populations in roots and soil, root-knot index and percent galled area were significant. Grain yield in all the treated plots was significantly higher than in the untreated plots. Seed treatment with neem seed powder and *T. harzianum* was the most effective of all the treatments.

Pigeonpea (*Cajanus cajan* (L.) Mill) is one of the most important pulse crops in the semi-arid tropics. The largest producer of pigeonpea in the world is India, where it is widely cultivated with minimal input of nutrients and pest management measures. The crop suffers damage due to diseases caused by *Meloidogyne incognita, Heterodera cajani* and *Fusarium udum* (Saxena and Reddy, 1987; Sharma and McDonald, 1990; Sikora and Greco, 1990; Sharma *et al.*, 1992, 1996; Ali and Askary, 2001; Dwivedi and Upadhyay, 2001; Shukla and Haseeb, 2002). Many control measures have been suggested (Yadava, 1986; Zaki and Bhatti, 1986; Sharma and Nene, 1990; Mishra, 1992; Whitehead, 1998; Chaudhary and Kumar, 1999), but cost-effective options for the management of these pests, especially under rain-fed conditions, have not been developed. Therefore, in an attempt to provide inexpensive and effective control measures for farmers, studies were conducted to evaluate biopesticides, bioagents and chemicals as seed treatments of pigeonpea cv. UPAS 120 under rain-fed conditions.

MATERIALS AND METHODS

The experiments were done for two years (June - November 2000 and 2001) at the research farm of the Aligarh Muslim University in the State of Uttar Pradesh in India and during 2001 at two farmer's fields in the district Bulandshahar (Uttar Pradesh State). In order to determine the initial nematode population density in the different experimental fields and the status of the soil, samples were collected using a metallic soil sampler from the top 15 cm soil from all the micro-plots (6 or 12 m^2) on the day of sowing. The number of cysts in 200 g soil was determined by catching cysts on an 80-mesh sieve (Sharma and Nene, 1986) and the population of all stages of parasitic nematodes was determined by combining sieving and Baermann funnel methods. To detect nematodes that were present only in lower numbers, the extract was concentrated into 20 ml of water and a 2-ml aliquot counted. Analysis of soil was done using the method of Pipper (1950) (Table I).

Seed of pigeonpea cv. UPAS 120 obtained from the Indian Institute of Pulses Research, Kanpur, India was treated with dimethoate 30 EC (8% v/w), chlorpyriphos 20 EC (1% v/w), triazophos 40 EC (3% v/w), neemark (5% v/w), neem (*Azadirachta indica* Juss.) seed powder (5% w/w), latex of *Calotropis procera* Bry. (1% v/w), or a spore suspension (10^8 spores/ml) of *Aspergillus niger* van Tiegh. and *Paecilomyces lilacinus* Thom. (2% v/w). Seeds were treated just before sowing by pouring/dusting treatment materials on seeds in a plastic vessel followed by thorough mixing with a limited amount of water and then dusted with chalk powder to dry the treated seeds. Carbofuran was applied into soil at the rate of 2 kg a.i./ha. In June 2000, treated seeds were sown at a row-to-row distance of 60 cm in 2 x 3 m *Meloidogyne incognita* (Kofoid *et* White) Chitw.–*Fusarium udum* Butler infested micro-plots. Untreated seeds were sown in four carbofuran treated plots and four untreated plots to serve as controls. There were four replicates for each treatment. After sowing, regular observations were made to record data on germination and the phytotoxic effects of any treatment on plants. Observations for disease symptoms were made regularly. The experiment was terminated at maturity, 150 days

after sowing, and data were recorded for root-knot index and nematode population in roots and soil. Grain yield data were recorded after threshing.

In 2001, another experiment was carried out in a *Heterodera cajani* Koshy and *M. incognita* infested experimental field at the Aligarh Muslim University. The plot size was 4 x 3 m. Two more experiments were carried out on farmer's fields at Arania and Wajidpur villages in the district Bulandshahar. At Arania, plot size was 5 x 5 m and at Wajidpur 8 x 5 m. However, data were recorded from areas of 12 m^2 for all these experiments. This year triazophos was not applied, and the spore suspension (10^8 spores/ml) of *A. niger* and *P. lilacinus* was applied at 1% v/w. Two new treatments, seed application of a spore suspension (10^8 spores/ml) of *Trichoderma harzianum* Rifai (1% v/w) and soil application of neem seed powder (50 kg/ha) were added in these experiments. Neem Jiwan was used in place of Neemark due to the non-availability of the latter. The crop was harvested at maturity, 170-175 days after sowing.

Data on general symptoms and occurrence of wilt were recorded 30, 45, 60, 90, 120 and 150 days after sowing. The number of *H. cajani* cysts and the nematode populations in roots and soil were recorded 45, 90 and 120 days after sowing and at harvest, while root-knot data were recorded only at harvest. Grain yield data were recorded after the pods were threshed.

The population of all stages of parasitic nematodes in 200 g soil from each plot was determined by combining sieving and Baermann funnel methods. Nematodes were extracted from 5 g of roots by macerating root tissues in a Waring blender (Southey, 1986) and all the developmental stages of all nematodes were counted collectively. Root-knot index was rated on a 0 to 4 scale where 0 = no galls, 1 = 1-25 % galled area, 2 = 26-50 % galled area, 3 = 51-75 % galled area and 4 = 75-100 % galled area (Taylor and Sasser, 1978). In order to determine root-knot index at harvest, roots of 20 plants from each replicate were carefully dug out, washed thoroughly, visually observed using a hand lens at 3-5 times magnification and, finally, fifty 1-cm root pieces from each replicate were observed under an Olympus Stereo-zoom Microscope (model SZX 9). The number of cysts in 200 g soil was determined by collecting cysts on an 80-mesh sieve.

The experiments were of completely randomized block design. The data were analyzed by analysis of variance (Cochran and Cox, 1957). Significant differences were determined using the LSD test at $P \leq 0.05$.

RESULTS AND DISCUSSION

No treatment affected seed germination or caused phytotoxicity. However, severe wilting of untreated plants was observed. Roots of such plants were found severely infected with *F. udum* and *M. incognita*. Seed treatment resulted in a significant reduction in wilting of pigeonpea during early stages of crop growth. Survival of plants in the early stages is very important as it influences the plant population and, consequently, yield.

Seed treatment with neem seed powder and soil application of carbofuran significantly reduced nematode populations in soil as compared to untreated plots (Table II). Root-knot index and percent galled area of roots were significantly suppressed by seed treatments with neem seed powder, neemark, *P. lilacinus* and soil application of carbofuran. *Fusarium* wilt incidence was similar in treated and untreated plots at harvest. However, all the treatments significantly increased grain yield as compared to untreated plots (Table II).

Seed germination, phytotoxicity and wilt incidence in the early stages of plant growth in 2001 were similar to the trial conducted in the year 2000. However, in these trials wilted plant roots were infected with *F. udum,*

Table I. Type of soil and initial nematode population at different experimental sites.

Experimental site	Soil type (% content)				Soil pH	Initial nematode population/200 g soil							*F. udum* cfu/g soil
	Sand	Silt	Clay	Organic matter		Cysts of *H. cajani*[1]	J2 of *M. incognita*[1]	*T. brassicae*[1]	*Hop. indicus*[1]	*Hel. indicus*[1]	*R. reniformis*[1]	*P. coffeae*[1]	
Aligarh experimental field 2000	71.2	16.0	11.5	1.3	7.7	--	60	10 (20)	10 (30)	--	0(20)	--	10^3
Aligarh experimental field 2001	71.0	16.0	11.5	1.5	7.6	26	50	10 (20)	10 (10)	--	0 (20)	--	10^4
Arania, Bulandshahar	61.5	16.4	19.8	2.3	7.3	22	30	20 (30)	20 (30)	0 (10)	--	0 (10)	10^3
Wajidpur, Bulandshahar	78.0	13.4	7.5	1.1	7.8	26	30	10 (10)	--	0 (20)	--	--	10^5

[1] Males outside brackets and females in brackets.

along with *H. cajani, M. incognita, Rotylenchulus reniformis* Linford & Oliveira and/or *Pratylenchus coffeae* (Zimm.) Filipjev *et* Stekh. Since *F. udum* infection in roots recorded at harvest was not different between treated and untreated plots, data are not presented in Tables III and V.

Crop growth was poor in the early stages of plant growth at Wajidpur due to poor soil fertility and the high population of *H. cajani.* Wilting of plants was severe during the period 30-60 days after sowing in untreated plots; the wilting continued in these plots and very few (35-45%) plants survived till harvest. Treated plots also had wilted plants, but much fewer than in untreated plots. The symptoms in the Aligarh and Arania trials were less severe than at Wajidpur.

At Aligarh, all the treatments, except latex of *C. procera,* significantly increased grain yield as compared to untreated plots (Table III). At Arania and Wajidpur,

Table II. Effect of different seed treatments on the grain yield of pigeonpea and populations of *Meloidogyne incognita, Tylenchorhynchus brassicae, Hoplolaimus indicus, Rotylenchulus reniformis* and infection of *Fusarium udum* in 2000.

Treatment	Grain yield (g/6 m^2)	Nematodes /g root	Nematodes /200 g of soil	Root-knot index	Per cent root galled area	Occurrence of *Fusarium* infection
Untreated	774	180	6400	0.85	21.3	100.0
Dimethoate	1128	180	6000	0.80	20.0	98.8
Chlorpyriphos	1096	170	6200	0.70	17.5	98.8
Triazophos	1165	180	6200	0.65	16.3	98.8
Neemark	1212	160	6000	0.60	15.0	97.5
Neem seed powder	1202	150	5800	0.55	13.8	97.5
P. lilacinus	1198	170	6000	0.60	15.0	98.8
A. niger	1212	160	5800	0.65	16.3	98.8
Latex of *C. procera*	1162	170	6200	0.80	20.0	100.0
Carbofuran	1136	30	2000	0.20	5.0	98.8
$LSD_{0.05}$	318	21.8	540	0.21	5.2	NS

Table III. Effect of seed treatments on the grain yield of pigeonpea and populations of *M. incognita, H. cajani, T. brassicae, H. indicus* and *Helicotylenchus indicus* at Aligarh in 2001.

Treatment	Grain yield (g/12 m^2)	Total nematode population/200 g soil		Nematode population/g root		Cysts/200 g soil		Galls per root at harvest	Root-knot index at harvest
		45 Days after sowing	At harvest	45 Days after sowing	At harvest	45 Days after sowing	At harvest		
Carbofuran	2070	160	1140	4	84	1	14	72	0.54
Neem seed powder (soil treatment)	1690	420	1880	7	149	1	19	98	0.73
Neem seed powder (seed treatment)	1620	440	1940	6	160	2	20	116	0.87
T. harzianum	1640	540	1920	6	165	2	19	133	1.00
Neem Jiwan	1570	580	1960	7	172	3	21	146	1.10
A. niger	1520	660	1980	8	166	2	23	151	1.13
P. lilacinus	1450	620	1960	9	170	3	23	148	1.11
Chlorpyriphos	1440	640	2480	22	185	4	25	162	1.22
Dimethoate	1410	720	2750	24	190	3	26	188	1.40
Latex of *C. procera*	1320	740	2890	29	192	4	29	208	1.56
Untreated	1260	960	3240	30	203	6	30	221	1.66
$LSD_{0.05}$	93.6	45.3	154.8	0.9	9.7	0.4	1.6	12.8	0.09

Table IV. Effect of seed treatments with nematode management components (biopesticides, chemicals and bioagents) on the grain yield of pigeonpea and population of *H. cajani, M. incognita, T. brassicae, Hoplolaimus indicus* and *Pratylenchus coffeae* at Arania in 2001.

Treatment	Grain yield (g/12 m^2)	Total nematode population/200 g soil		Nematode population/g root		Cysts/200 g of soil		Root- knot index at harvest
		45 Days after sowing	At harvest	45 Days after sowing	At harvest	45 Days after sowing	At harvest	
Carbofuran	3310	310	800	15	117	20	42	0.48
Neem seed powder (soil treatment)	2720	415	1220	18	139	22	48	0.61
Neem seed powder (seed treatment)	2360	515	1360	17	145	26	62	0.93
T. harzianum	2240	620	1430	20	145	27	63	0.98
Neem Jiwan	2080	535	1280	24	154	27	64	1.17
A. niger	1980	610	1750	26	156	30	65	1.29
P. lilacinus	1900	630	1910	30	157	36	66	1.30
Chlorpyriphos	1940	675	1920	27	175	32	66	1.29
Dimethoate	1780	725	2040	31	183	32	70	1.36
Latex of *C. procera*	1520	790	2040	30	181	33	73	1.39
Untreated	1060	920	2160	44	202	37	78	1.52
$LSD_{0.05}$	126.9	48.1	152.0	1.9	9.7	1.8	4.1	0.11

grain yield was significantly increased by all the treatments (Tables IV and V). Nematode populations in roots and soil, number of cysts in soil and root-knot index were significantly suppressed by all the treatments, except for the latex treatment (Tables III, IV, V).

The results indicated that application of carbofuran was the most effective treatment, followed by neem seed powder (soil application), seed treatment with neem seed powder, Neem Jiwan, *T. harzianum, A. niger, P. lilacinus,* chlorpyriphos, dimethoate, and latex, respectively. *Heterodera cajani, M. incognita, R. reniformis, Tylenchorhynchus brassicae* Siddiqi, *Hoplolaimus indicus* Sher, *Helicotylenchus indicus* Sher and *P. coffeae* reproduced well in untreated plots during the cropping period. Suppression of their populations was achieved by all the treatments.

The composition of the nematode population was different at the three experimental sites. In untreated plots, the total nematode population at harvest was 2,400/200 g of soil at Wajidpur, 2,160 at Arania and 3,240 at Aligarh. The highest population of *H. cajani* cysts was 84/200 g of soil at Wajidpur followed by 78 at Arania and 30 at Aligarh. The population of second stage juveniles of *M. incognita* was 680/200 g soil at Wajidpur, 820 at Arania and 920 at Aligarh. Among other nematodes, *T. brassicae* was the dominant species of populations in all the fields, followed by *R. reniformis, Hoplolaimus indicus, Helicotylenchus indicus* and *P. coffeae,* respectively.

Effective and easily affordable seed treatments were identified by this study. Chaudhary and Kumar (1999) and Mishra and Majumder (2001) also made similar observations. No seed treatment assisted plant growth or suppressed nematode population build-up for more than 50-75 days but their effectiveness during the early growth period was important and contributed to differences in yield. The seed treatments reduced early wilting and, as a result, plant population and yield were not adversely affected.

ACKNOWLEDGEMENT

Financial Assistance from Indian Council of Agricultural Research, New Delhi under 'National Agricultural Technology Project No. RPPS-2' entitled, "Integrated management of plant nematodes/soil pathogens in pulses based cropping systems" is gratefully acknowledged in carrying out the present studies.

Table V. Effect of seed treatments on the grain yield of pigeonpea and population of *H. cajani, M. incognita, T. brassicae* and *Helicotylenchus indicus* at Wajidpur in 2001.

Treatment	Grain yield (g/12 m^2)	Total nematode population/200 g soil		Nematode population/g root		Cysts/200 g of soil		Root- knot index at harvest
		45 Days after sowing	At harvest	45 Days after sowing	At harvest	45 Days after sowing	At harvest	
Carbofuran	3240	170	680	5	73	22	32	0.25
Neem seed powder (soil treatment)	2980	195	1200	8	98	32	56	0.33
Neem seed powder (seed treatment)	2530	410	1700	9	103	24	66	0.67
T. harzianum	2480	560	1960	13	110	28	72	0.79
Neem Jiwan	2470	540	1920	16	123	26	68	0.83
A. niger	2410	720	1960	18	127	30	72	0.85
P. lilacinus	2300	640	2040	19	130	32	74	0.89
Chlorpyriphos	2030	840	2200	30	148	30	74	1.03
Dimethoate	1860	900	2340	23	165	30	76	1.30
Latex of *C. procera*	1340	1060	2280	24	184	30	76	1.20
Untreated	680	1120	2400	29	193	48	84	1.41
$LSD_{0.05}$	147.4	63.2	131.1	1.4	10.3	2.2	5.7	1.00

LITERATURE CITED

Ali S.S. and Askary T.H., 2001. Taxonomic status of nematodes of pulse crops. Pp. 197-216 *In*: Nematode Taxonomy – Concepts and Recent Trends (Jairajpuri M.S. and Rahaman P.F. eds). I.Q. Printers, Hyderabad, India.

Chaudhary R.G. and Kumar K., 1999. Potentials of biocontrol agents against wilt in pre-*rabi* pigeonpea crop. *Indian Journal of Plant Pathology, 17*: 67-69.

Cochran W.G. and Cox G.M., 1957. *Experimental Designs.* John Wiley and Sons, Inc., New York, U.S.A., 611 pp.

Dwivedi K. and Upadhyay K.D., 2001. Population dynamics of *Heterodera cajani* associated with pigeonpea in various cropping systems of central Uttar Pradesh. *Indian Journal of Nematology, 31*: 120-121.

Mishra S.D., 1992. Nematode pests of pulse crops. Pp. 139-148 *In*: Nematode Pests of Crops (Bhatti D.S. and Walia R.K. eds). C.B.S. Publishers & Distributors, Delhi, India.

Mishra S.D. and Majumder V., 2001. Seed coating of pigeonpea with neem formulations for the management of *Heterodera cajani* and other phytoparasitic nematodes. *Current Nematology, 12*: 15-19.

Pipper C.S., 1950. *Soil and Plant Analysis.* International Scientific Publishers., Inc., New York, U.S.A., 368 pp.

Saxena R. and Reddy D.D.R., 1987. Crop losses in pigeonpea and mungbean by pigeonpea cyst nematodes, *Heterodera cajani. Indian Journal of Nematology, 17*: 91-94.

Sharma S.B. and McDonald D., 1990. Global status of nematode problems of groundnut, pigeonpea, chickpea, sorghum and pearl millet and suggestions for future work. *Crop Protection, 9*: 453-458.

Sharma S.B. and Nene Y.L., 1986. Extraction of *Heterodera cajani* cysts using modified sieving technique. *Indian Journal of Nematology, 16*: 123-124.

Sharma S.B. and Nene Y.L., 1990. Effect of solarization on nematodes parasitic to chickpea and pigeonpea. Supplement to *Journal of Nematology, 22*: 658-664.

Sharma S.B., Ali S.S., Upadhyay K.D. and Ahmad F., 1996. Potential nematode constraints of pigeonpea in Uttar Pradesh in Northern India. *Afro-Asian Journal of Nematology, 6*: 151-155.

Sharma S.B., Smith D.H. and McDonald D., 1992. Nematode constraints of chickpea and pigeonpea production in semi-arid tropics. *Plant Disease, 76*: 868-874.

Shukla P.K. and Haseeb A., 2002. Survey of farmer's fields for the association of plant parasitic nematodes and wilt fungi with pigeonpea and quantification of losses. *Indian Journal of Nematology, 32*: 162-164.

Sikora R.A. and Greco N., 1990. Nematode parasites of food legumes. Pp. 181-235. *In*: Plant Parasitic Nematodes in Subtropical and Tropical Agriculture (Luc M., Sikora R.A. and Bridge J. eds). CAB International, Wallingford, U.K.

Southey J.F., 1986. *Laboratory Methods for work with Plant and Soil Nematodes.* Ministry of Agric. Fish. & Food, HMSO, London, U.K., 202 pp.

Taylor A.L. and Sasser J.N., 1978. *Biology, identification and control of root-knot nematodes (Meloidogyne species).* Department of Plant Pathology, North Carolina State University and U.S. Agency for International Development, Raleigh, North Carolina, U.S.A., pp. 111.

Yadava B.S., 1986. Nematode problems of pulse crops. Pp. 328-335 *In*: Plant Parasitic Nematodes of India (Swarup G. and Dasgupta D.R. eds). Allied Publishers, New Delhi, India.

Whitehead A.G., 1998. *Plant Nematode Control.* CAB International, Wallingford, U.K., 384 pp.

Zaki F.A. and Bhatti D.S., 1986. Control of pigeonpea cyst nematode, *Heterodera cajani* Koshy, 1967 by chemical seed treatment. *Indian Journal of Nematology, 16*: 106-108.

Accepted for publication on 6 August 2004.