Natl. Acad. Sci. Lett. (September–October 2020) 43(5):409–412
https://doi.org/10.1007/s40009-020-00895-2

SHORT COMMUNICATION

Crop Loss Estimations due to Plant-Parasitic Nematodes in Major Crops in India

Vinod Kumar[1] · Matiyar Rahaman Khan[2] · R. K. Walia[1]

Received: 18 August 2017 / Revised: 6 April 2018 / Accepted: 9 January 2020 / Published online: 29 January 2020
© The National Academy of Sciences, India 2020

Abstract Plant-parasitic nematodes are a major biotic stress in successful crop cultivation. All India Coordinated Research Project (AICRP) on Nematodes in Cropping Systems is entrusted with developing nematode management technologies for varied agro-climatic zones. A precise assessment of crop losses caused by nematodes to crops and periodic update of the same are useful to fix research priorities, besides serving as a benchmark for policy planners/funding agencies for research support and public/private sector to make appropriate investments for developing nematode management products. Based on data generated through AICRP on Nematodes over the years, a critical analysis has been made on losses in different crops. Overall, plant-parasitic nematodes cause 21.3% crop losses amounting to Rs. 102,039.79 million (1.58 billion USD) annually; the losses in 19 horticultural crops were assessed at Rs. 50,224.98 million, while for 11 field crops it was estimated at Rs. 51,814.81 million. Rice root-knot nematode, *Meloidogyne graminicola*, was economically most important causing yield loss of Rs. 23,272.32 million in rice. Citrus (Rs. 9828.22 million), banana (Rs. 9710.46 million) among fruit crops; and tomato (Rs. 6035.2 million), brinjal (Rs. 3499.12 million) and okra (2480.86 million) among the vegetable crops suffered comparatively more losses.

✉ R. K. Walia
raman261156@gmail.com

[1] All India Coordinated Project on Nematodes in Cropping Systems, ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

[2] Division of Nematology, ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

Keywords Crop losses · Plant-parasitic nematodes · Horticultural crops · Field crops · Root-knot nematode · *Meloidogyne* spp.

Plant-parasitic nematodes are a major biotic factor limiting crop productivity and ultimately crop production. Besides inflicting direct losses in crop yields, plant-parasitic nematodes also play an important role in disease complexes involving other pathogens. The expression of damage in crop plants due to nematodes often goes unnoticed for want of diagnostic symptoms. The estimation of crop losses due to nematodes is also cumbersome, and precise techniques for the same still remain elusive. Nevertheless, several reports are available on this aspect; the most widely quoted is the one by Sasser and Freckman [1]. According to them, plant-parasitic nematodes cause on an average 12.3% losses annually in 40 major crops at a global level; the losses are more in developing countries (14.6%) than in developed nations (8.8%). Based on this comprehensive survey on a global scale, the annual economic crop yield losses due to plant-parasitic nematodes in major crops have been estimated to be USD 173 billion [2].

All India Coordinated Research Project (AICRP) on Nematodes is a discipline-oriented project that aims to develop nematode management technologies for economically important nematodes in major crops through multilocational trials in different agro-climatic regions of India. Under the aegis of this project, loss estimations due to nematodes in different crops are a continuous program operating at 18 centers of the project across the country. Field trials on loss estimations employing t tests are conducted regularly in various crops in different seasons using nematicidal product (carbofuran) at varying initial nematode populations (> economic threshold level). The details

of methodology employed for conducting loss estimation trials under AICRP (Nematodes) are available in [3]. The enormous data generated under this program have been compiled in a technical bulletin [4]. Expression of crop losses in monetary terms is essential for project formulations and helps in showcasing, convincing and seeking research support from policy planners. This exercise has to be done periodically to offset the inherent aberrations due to temporal parameters such as crop production, areas under crop production and fluctuations in minimum support price (MSP).

The information generated up to 2004–2005 under the aegis of AICRP on Nematodes has been compiled previously [5]. According to this, the yield losses in 24 different crops amounted to Rs. 21,068.73 million annually; rice alone suffered losses to the extent of Rs. 4779 million. We have attempted to update the information on current basis, and the same is presented in this note.

Data on area, production, yield of principal crops, and MSP of various agricultural commodities have been obtained from most reliable sources [6–8]. Barring a few crops such as ginger, turmeric [9], sunflower [10] and papaya [11], the data generated by AICRP on Nematodes have been used for assessment of yield losses. Loss estimations varied for each crop according to locations, seasons and years; therefore, data obtained from different centers were averaged for calculations. Out of total area for a particular crop, only 10% has been considered as nematode infested and the same has been used for calculations of yield losses.

A perusal of data presented in Table 1 reveals that overall economic losses in 30 crops amount to Rs. 102,039.79 million annually; the losses in 19 horticultural crops were assessed at Rs. 50,224.98 million, while for 11 field crops it was estimated at Rs. 51,814.81 million. The mean percent losses were higher in horticultural crops, i.e., 23.03% (fruits 25.5%, vegetables 19.6%, spices 29.5%) than in field crops, i.e., 18.23% (cereals 18.8%, pulses 23%, oilseeds 11.8%, fiber crops 19.75%). The economic losses in rice due to rice root-knot nematode, *Meloidogyne graminicola*, alone were maximum (Rs. 23,272.32 million) among all the crops and nematodes considered. In wheat, avoidable losses due to cereal cyst nematode, *Heterodera avenae*, in Rajasthan and Haryana (the major *molya* disease affected states) were calculated at Rs. 8967.52 million. Wheat seed gall nematode, *Anguina tritici*, has been excluded from this study, since it has already been eradicated from Punjab, Haryana and western UP and only sporadic incidences are reported from other wheat growing areas of the country. Citrus (Rs. 9828.22 million), banana (Rs. 9710.46 million) among fruit crops; and tomato (Rs. 6035.2 million), brinjal (Rs. 3499.12 million) and okra (2480.86 million) among the vegetable crops suffered comparatively more losses that is partly attributable to areas of production in respect of these crops. Potato cyst nematode, *Globodera rostochiensis* and *Globodera pallida* are restricted but widespread in the Nilgiri Hills of south India. As per current information, potato crop is grown in about 1440 ha in the Nilgiris [12] and the same has been considered for loss assessment that amounts to Rs. 127.04 million.

It is clearly discernible from the data in Table 1 that root-knot nematodes (*Meloidogyne* spp.) alone are responsible for Rs. 77,373.87 million losses in different crops that constitutes about 75.83% of the total estimated losses, thus proving to be the economically most important of all the plant-parasitic nematodes.

Some more interesting facts can be deduced when this data as compared with that reported earlier [5]. First is an overall increase of 4.84 times in economic losses since 2007 that is attributable to escalation in MSP, increase in area under cultivation, and additional crops included in the study, etc. Second is the emergence of *M. graminicola* as most important and national problem of rice relegating *Aphelenchoides besseyi*, *Ditylenchus angustus* and *Hirschmanniella* spp.; however, *A. besseyi* is certainly important in some states (Assam, West Bengal, Odisha, Madhya Pradesh, Gujarat and Chhattisgarh). Third is a relatively more shift toward horticulture, and therefore, nematode problems in these cropping systems.

It is emphasized here that the figures presented in this note pertain to quantitative losses only. The qualitative losses such as forking in carrots, infection in underground edible plant parts like tubers in potato, rhizomes in turmeric, ginger, etc., often result in non-acceptability of produce at the level of consumers; such parameters have not been taken into account while assessing losses due to nematodes. Furthermore, the information on nutritional quality parameters in crop produce due to nematodes is totally lacking. Nevertheless, the information compiled and presented in this paper would serve as an important tool to consider research investments for public/private sectors *vis-à-vis* monetary losses. Besides, private sector engaged in production of chemical and biological products for nematode management may find it useful for planning appropriate inputs in different crops and areas.

The methods employed for estimation of crop losses due to pests and diseases in general, and plant-parasitic nematodes in particular, are often subjected to criticism for want of precision. The debate on role of "other pests and pathogens" prevalent under field conditions (other than the target pest) is justified. However, the product used in treated plots (carbofuran in this case) is most appropriate for the purpose where only target nematode is the major pest (hot spot for nematode). The impact of other pests and diseases is uniform across the treated and untreated plots.

Table 1 Estimated losses due to economically important plant-parasitic nematodes to various crop in India (2014–2015)

S. no.	Crop	Nematode affecting the crop	Production in million tons	Percent yield loss	Average no. of markets surveyed	Price per metric ton	Monetary loss (Rs. in million)
Fruit crops							
1.	Banana	*Meloidogyne incognita*	02.92 (29.22)	15	810	22,170	9710.46
2.	Citrus	*Tylenchulus semipenetrans*	01.16 (11.65)	27	810	31,380	9828.22
3.	Grapes	*Meloidogyne incognita*	00.28 (02.82)	30	810	46,910	3940.44
4.	Guava	*Meloidogyne* spp.	00.40 (03.99)	28	810	20,990	2350.88
5.	Papaya	*Meloidogyne incognita* + *Rotylenchulus reniformis*	00.49 (04.91)	30	810	17,120	2516.64
6.	Pomegranate	*Meloidogyne* spp.	00.18 (01.78)	23	810	73,030	3023.44
			Mean Fruit Crops	25.5		Total fruit crops	31,370.08
Vegetable crops							
7.	Bittergourd	*Meloidogyne incognita*	00.08 (00.77)	13.5	1246	23,410	252.82
8.	Bottlegourd	*Meloidogyne incognita*	00.19 (01.82)	22	1246	9660	403.78
9.	Brinjal	*Meloidogyne* spp.	01.25 (12.58)	21	1246	13,330	3499.12
10.	Capsicum	*Meloidogyne* spp.	00.02 (00.18)	10	1246	26,460	52.92
11.	Carrot	*Meloidogyne* spp.	00.10 (00.96)	34	1246	22,180	754.12
12.	Chili	*Meloidogyne* spp.	00.20 (01.99)	15	1170	24,830	744.90
13.	Cucumber	*Meloidogyne* spp.	00.07 (00.67)	12	1246	13,150	110.46
14.	Okra	*Meloidogyne* spp.	00.57 (05.70)	19.5	1246	22,320	2480.86
15.	Potato[a]	*Globodera* spp.	0.032 (0.032)	26	1246	15,270	127.04
16.	Tomato	*Meloidogyne* spp.	01.64 (16.38)	23	1246	16,000	6035.20
			Mean vegetable crops	19.6	Total vegetable crops		14,461.22
Spices							
17.	Ginger	*Meloidogyne incognita*	00.08 (00.76)	29–33	1170	75,170	1894.28
18.	Pepper	*Radopholus similis*	0.006 (00.06)	24	1170	605,450	871.84
19.	Turmeric	*Meloidogyne incognita*	00.08 (00.83)	33	1170	61,650	1627.56
			Mean spices	29.5		Total spices	4393.68
			Mean horticultural crops	23.03		Total horticultural crops	50,224.98
Cereal crops							
20.	Maize	*Heterodera zeae*	02.41 (24.17)	12	MSP	13,100	3788.52
21.	Rice	*Meloidogyne graminicola*	10.54 (105.48)	16	MSP	13,800	23,272.32
22.	Wheat[b]	*Heterodera avenae*	02.17 (21.71)	28.5	MSP	14,500	8967.52
			Mean Cereal Crops	18.8		Total Cereal Crops	36,028.36
Pulse crops							
23.	Black gram	*Meloidogyne incognita*	00.19 (01.96)	19	MSP	43,500	1570.35
24.	Chickpea	*Meloidogyne incognita*	00.73 (07.33)	21	MSP	31,750	4867.27
25.	Green gram	*Meloidogyne incognita*	00.15 (01.50)	29	MSP	46,000	2001.00
			Mean Pulse Crops	23		Total pulse crops	8438.62
Oilseed crops							
26.	Castor	*Rotylenchulus reniformis*	00.18 (01.87)	15	Agriwatch, 2015	40,103	1082.78
27.	Groundnut[c]	*Meloidogyne arenaria*	00.22 (02.20)	4.5	MSP	40,000	396.00

Table 1 continued

S. no.	Crop	Nematode affecting the crop	Production in million tons	Percent yield loss	Average no. of markets surveyed	Price per metric ton	Monetary loss (Rs. in million)
28.	Sunflower	*Meloidogyne incognita*	00.04 (00.43)	16	MSP	37,500	240.00
			Mean oilseed crops	11.8		Total oilseed crops	1718.78
Fiber crops							
29.	Cotton	*Meloidogyne incognita/ Meloidogyne javanica*	00.59 (05.91)	20.5	MSP	39,000	4717.05
30.	Jute	*Meloidogyne* spp.	00.20 (02.00)	19	MSP	24,000	912.00
			Mean fiber crops	19.75		Total fiber crops	5629.05
			Mean field crops	18.23		Total field crops	51,814.81
			overall mean	21.30		Grand total	102,039.79

Figures on production and minimum support price (MSP) have been taken from Anonymous (2016) and AGMARKETNET Portal (2014). Loss estimations are based mainly on work done at various centers of AICRP on Nematodes. Only ten percent area of total production infested with phytonematodes has been considered for estimation of national losses. Figures in parentheses are total production of the crops in country

[a]*Globodera* spp. is widespread only in Nilgiri Hills (Tamil Nadu), so the area, production of Nilgiri hills only has been considered

[b]Production in Rajasthan and Haryana states only taken into consideration

[c]Production in Gujarat state only taken into consideration

Conducting such trials in "closed environments" involving only the target pest may be unrealistic because the nematode effects are liable to be influenced by prevailing biotic and abiotic stresses under field conditions.

This note depicts significance of plant-parasitic nematodes in Indian agriculture. In a recent report, the annual overall losses to crops considering all pests and diseases in India were projected at Rs. 500 billion [13]; the relative proportion attributable to plant-parasitic nematodes as per this study amounts to approximately 20.4 percent that is fairly accurate assessment. Further, in a recent feedback from various centers of AICRP (Nematodes) in India, the adoption rate of nematode management technologies is meager 28 percent. Considering the overall losses projected in this study (Rs. 102,039.79 million = USD 1.58 billion), the monetary benefits accrued by adoption of nematode management technologies work out to Rs. 28,571.14 million. The information generated through this study will help in focusing on nematodes as a serious constraint in Indian agriculture scenario, as well as to fix research priorities.

References

1. Sasser JN, Freckman DW (1987) A world perspective of Nematology: the role of Society. In: Veech JA, Dickson DW (eds) Vistas on Nematology Society of Nematologists, USA, pp 7–14
2. Elling AA (2013) Major emerging problems with minor *Meloidogyne* species. Phytopathology 103:1092–1102
3. Anonymous (2015) Datasheets and methodologies for technical programme (2015–17). Project Coordinating Cell, AICRP on Nematodes ICAR-IARI New Delhi, p 105
4. Singh AU (2015) Yield losses in crops due to phytonematodes. Project Coordinating Cell, AICRP on Nematodes ICAR-IARI, New Delhi, p 36
5. Jain RK, Mathur KN, Singh RV (2007) Estimation of losses due to plant parasitic nematodes on different crops in India. Indian J Nematol 37:219–221
6. Anonymous (2016) Pocket book of agricultural statistics. Govt. of India, Ministry of Agriculture & Farmers' Welfare, Department of Agriculture & Cooperation, Directorate of Economics & Statistics, Krishi Bhawan, New Delhi, p 154
7. Anonymous (2014) AGMARKETNET Portal - Commodity-wise, month-wise arrival and price of horticulture produce. (www.agmarketnet.nic.in/nhm/horticulture.aspx)
8. Anonymous (2015) *Agriculture statistics at a glance*. Govt. of India, Ministry of Agriculture & Farmers' Welfare, Department of Agriculture & Cooperation, Directorate of Economics & Statistics, Krishi Bhawan, New Delhi, 507 pp
9. Ray S, Mohanty S, Mahapatra SN, Patnaik PR, Ray P (1995) Yield loss in ginger and turmeric due to root-knot nematode, *Meloidogyne incognita*. J Spices Aromat Crops 4:67–69
10. Devappa V, Krishnappa K, Reddy BMR (1998) Estimation of avoidable losses due to root-knot nematode, *Meloidogyne incognita* in sunflower. Indian J Nematol 28:95
11. Jonathan EI, Balasubramanian TP, Wilfred MW (2001) Nematode menace in papaya. The Hindu. March, 2001 (www.thehindu.com/2001/03/22/stories/0822042h.htm)
12. Anonymous (2016) District statistical handbook (2015–16)—the Nilgiris district. Department of Economics and Statistics, p 157 (nilgiris.nic.in/images/districthandbook.0809.pdf)
13. Anonymous (2014) Associated Chambers of Commerce and Industry of India (croplife.org/news/keeping-indias-pests-in-line)

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.