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POTATO STEM NEMATODE IN BELARUS

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Abstract

Potato stem nematode is spread unevenly in Belarus and occurs mostly in Minsk region. The degree of the disease severity depends on seed tuber infection. Yield losses due to tuber infection by *D. destructor* may be as high as 43.3%. The system for the control of this parasite has been proposed, which includes the use of physical, agrotechnical and chemical measures, allowing a reduction of disease incidence and severity by 96.3–98.3% and production of high-quality seed material.

Key words: potato, nematode, *Ditylenchus*, disease incidence and severity, protection.

Introduction

At present potato stem nematode is one of the most harmful potato phytho-helminth diseases in Belarus. It is of special relevance for potato seed production. In the lots of elite seed material, the presence of tubers infected by *D. destructor* is not allowed and in reproduction lots their number must not exceed 0.5% /Иванюк и др., 2007/. As a result, a need for a detailed study of *Ditylenchus* incidence and severity, determination of specific composition of disease casual agents, development of new effective disease control strategies has arisen.

Materials and Methods

Determination of *Ditylenchus destructor* Thorne incidence and severity was carried out during potato survey on farms of Belarus using methods of tuber analysis 3–4 weeks after harvesting and 30–40 days before planting. From each stored potato lot of up to 10 tons in weight, 200 tubers were collected from not less than 10 different places. For lots of large weight for each next 10 tons 50 tubers were additionally picked from not less than four places. In each point, an equal number of tubers was taken randomly /Иванюк и др., 2005/.

Incidence of disease on potato tubers was determined as:

$$P = \frac{n}{N} \times 100,$$

where P is the disease incidence (%),
n is the number of infected tubers in the sample,
N is the total number of tubers in the sample.

Intensity of stem nematode severity on tubers was calculated as:

$$R = \frac{\sum(a \times b)}{N \times K} \times 100,$$

where R – disease severity, %

$\Sigma(a \times b)$ – the sum of products of quantity of infected tubers (a) and corresponding index of their infection,

N – the total number of inspected tubers,

K – the highest infection index of the scale.

The stem nematode harmfulness was estimated by comparing the yield obtained from healthy and infected seed tubers. For the determination of *D. destructor* harmfulness, a strongly infected middle-ripening cultivar 'Lugovskoy' was used. 30 healthy tubers (infection index 0) and 30 infected with the infection index 1, 2 and 3 – weak, middle and strong degree accordingly -were planted. Disease incidence and severity, and yield were recorded.

For the determination of species structure of nematodes – infection agents – funnel method was used, by means of which nematodes were extracted from the tuber tissues, located at the border of infected and healthy parts. Thermal anesthesia of infection agent was made at 55^{o} C. For the analysis of specimen 100x, 400x, 1000x power microscope Leica DMLS was used.

Possibility of use of thermotherapy for *D. destructor* control was determined experimentally under field and laboratory conditions by means of dry and wet treatment of potato tubers infected by stem nematode at different degree at temperatures of 20 (control) 40, 45 and 50^{o} C for 1 and 2 hours.

One part of warmed tubers was examined for residual number of *D. destructor* live individuals, the other – was planted in the field. In the autumn, after harvesting the disease incidence and severity were estimated.

The efficacy of biological means of plant protection (trichodermin, nemabact, micolin, diprin), chemicals (prestige, percaltsit, izapin), micro-and macroelements ($CuSO_4$, H_3BO_3, $KMnO_4$), double superphosphate, boron-copper fertiliser), plant growth regulators (turf oxidate) and also autumn and spring greenbelt setting for stem nematode control were determined in the field conditions. One part of preparation was used for seed tuber treatment before planting (trichodermin 100 g/5l of water, nemabact 3 ml/3l, micolin (100 ml/1l of water), diprin 3 ml/3l, prestige 5 ml/5l, izapin 1 ml/1l, $CuSO_4$ (0.6% sol.) 15 g/2.5l, H_3BO_3 (0.5% sol.) 12.5 g/2.5l, $KMnO_4$ (0.3% sol.) 12.5g/2.5l, double superphosphate (4% sol.) 200g/5l, boron-copper fertiliser (0.5% sol.)12.5 g/2.5l, turf oxidate (0.03–0.05% sol.) 3.5 ml/5l of water), the others were applied into the soil or used for plants spraying during vegetation period (trichodermin 10g in the hole, percaltsit 300 g m^{-2}, izapin 1ml/1l of water). Infestation background was made by applying during planting 45–55 g milled tubers infected by D. *destructor* under each tube. The level of invasion was 120–180 nematode agents per one gram of applied material. Determination of tuber infection of new yield was performed after harvesting.

Biological efficacy of plant protection measures was calculated as:

$$B = \frac{P - P_1}{P_1},$$

where B – biological efficacy, %

P and P_1 – indices of disease development in the control and the test, %

Statistical data processing was performed by the analysis of variance and correlation using statistical software.

Results and Discussion

Tuber infection caused by *Ditylenchus* is spread in Belarus unevenly. The disease occurs most heavily in Minsk region. Tuber infection caused by stem nematode in this region was identified in 69.7% of all examined lots of seed material. In Brest region this index was 26.6; in Gomel region 29.4; Mogilev 30.0: in Vitebsk 33.3%. In Grodno region stem nematode was not found on potato tubers.

Our studies showed that the higher level of seed material infestation resulted in the higher disease incidence and severity on the new yield tubers. So, when planting weakly infected tubers (infection index 1) disease incidence and severity increased by 12.3 and 3.8%, moderately infected (infection index 2) – 30.4 and 6.6% and strongly infected (infection index 3) – 35.2 and 7.4%, accordingly. Potato yield was reduced by 16.4%, 20.5 and 43.3%, accordingly (Tables 1, 2).

Table 1. The influence of seed tuber infection on *Ditylenchus* incidence and severity on the tubers of the new yield (cv. ʻLugovskoy', 2003–2005)

Infection index of mother tubers	Stem nematode incidence on new yield tubers		Stem nematode severity	
	%	Deviation from control %	%	Deviation from control %
0	5.6	–	0.5	–
1	17.9	+12.3	4.3	+3.8
2	36.0	+30.4	7.1	+6.6
3	40.8	+35.2	7.9	+7.4
LSD_{05}	9.2	–	2.2	–
r±Sr	0.9757±0.1549	–	0.9865±0.1157	–

Table 2. The influence of seed tuber infection on potato yield (cv. ʻLugovskoy', 2003–2005)

Infection index of mother tubers	Yield		
	$t\ ha^{-1}$	Deviation from control	
		$t\ ha^{-1}$	%
0	267,9	–	–
1	224.0	–43.9	–16.4
2	213.0	–54.9	–20.5
3	151.9	–116.0	–43.3
LSD_{05}	39.7	–	–
r±Sr	–0.9771±0.1505	–	–

Statistical analyses of the obtained results showed that potato yield had an inverse negative correlation (r±Sr = –0.9454±0.2304; r±Sr = –0.9907±0.0962; r±Sr = –0.9771±0.1505), and disease incidence and severity on new yield tubers – direct correlation (r±Sr = 0.9757±0.1549; r±Sr = 0.9865±0.1157) with the degree of stem nematode severity on seed tubers.

Besides usual disease symptoms in the conditions of Belarus, for the first time we registered disease symptoms as deeply penetrating into the tubers brown coloured injuries, with the typical accumulation of nematode in the form of white-coloured powder-like mass on the margins (Figure a, b). It has been determined that deep form on the tubers is caused by *Ditylenchus dipsaci (*Kuhn, 1857) Filipjev, 1936. It has been proved that in the conditions of Belarus, potato tubers infestation with *D. dipsaci* has a local character and at present is recorded only in Minsk region on two cultivars ʻScarb' and ʻOrkchideya'.

In spite of the rare occurrence in the conditions of Belarus, the ability of *D. dipsaci* to invade potato tubers together with *D. destructor* and to increase disease severity complicates control measures, reduces the range of potato fore-crops, extends the number of host-plants on which casual organisms can develop. Taking into account the characteristics of 2002 and 2005 vegetative periods it can be claimed that potato tubers infestation with stem nematode is favoured by hot dry weather conditions and moisture deficiency in the soil.

a **b**

a – casual form, *b* – deep form

Figure. Stem nematode symptoms on potato tubers (cv. ʻScarb')

To reduce stem nematode infestation we worked out a complex of measures directed to its pathogenic activity reduction: thermotherapy, tubers greenbelt setting, and seed material treatment with chemical, biological preparations, macro and micro elements.

It has been determined that in all cases under thermal treatment of infected tubers a reduction of stem nematode live individuals takes place. Full control of *D. destructor* was registered only in the case of dry thermal potato treatment (at temperatures 45 and 50^o C), and also under humid warming (50^o C) for 2 hours (Table 3).

A 2-hour thermal treatment of potato seed material affected by *D. destructor* at different degree favoured considerable reduction of disease onset on new yield tubers.

The use of wet warming at 50° C was the most efficient for that. Biological efficacy of this method in these treatments was 100%.

Table 3. The influence of thermal treatment of potato seed tubers on stem nematode

Method of treatment	t, °C	Residual number of live nematodes, number/1 g of affected tissue		Disease incidence %	Biological efficacy %
		exposition 1 hour	exposition 2 hours		
Weekly affected seed tubers					
Control	20	2440	2440	15.4	–
	40	680	506	12.5	18.8
Wet	45	106	115	0	100.0
	50	160	0	0	100.0
	40	602	282	14.3	7.1
Dry	45	330	0	6.2	59.7
	50	170	0	0	100.0
LSD_{05}				4.9	–
Moderately affected seed tubers					
Control	20	3220	3220	81.2	–
	40	410	300	50.0	38.4
Wet	45	88	176	50.0	38.4
	50	208	0	28.6	64.8
	40	714	203	75.0	7.6
Dry	45	544	0	56.2	30.8
	50	270	0	7.1	91.2
LSD_{05}				12.6	–
Strongly affected seed tubers					
Control	20	2760	2760	100.0	–
	40	870	506	92.8	7.2
Wet	45	436	316	83.3	16.7
	50	68	0	72.7	27.3
	40	810	210	57.1	42.9
Dry	45	748	0	56.2	43.8
	50	460	0	6.2	93.8
LSD_{05}				14.7	–

Dry warming using weakly affected tubers at 45° C and moderately and strongly affected tubers at 50° C did not favour a full recovery of the new yield from stem nematode, but let us reduce its display to a considerable extent. Biological efficacy of thermal treatment in these cases ranged from 59.7 to 93.8%.

It should be mentioned that dry warming of seed tubers proved to be more efficient for the control of phythohelminth invasion compared with wet warming. So, biological efficacy of dry warming, on the average, was 53.0%, whereas that of wet warming – 45.7%.

The preparations micolin and nemabact used as seed potato treaters exerted a significant inhibiting effect on stem nematode infestation on potato tubers. Their biological efficacy was as high as 32.4 and 49.4%, accordingly (Table 4).

Table 4. The influence of biological preparations on stem nematodes on potato tubers

Treatment	Disease incidence %	Biological efficacy %
Control (water)	25.3	–
Prestige (standard)	17.5	30.8
Lignorin	23.9	5.5
Micolin	17.1	32.4
Trikchodermin	27.0	-6.7
Diprin	20.9	17.4
Nemabact	12.8	49.4
LSD_{05}	8.0	–

Among the tested chemicals used against potato stem nematode on artificial infestation background the highest protective effect was shown by percaltsit (soil application during planting) and izapin (seed tuber treatment + spraying during potato vegetation period): biological efficacy – 41.9 and 34.4%, correspondingly (Table 5).

Table 5. The influence of chemicals on stem nematodes on potato tubers

Treatment	Disease incidence %	Biological efficacy %
Control (water)	25.3	–
Prestige (standard)	17.5	30.8
Percaltsit	14.7	41.9
Izapin (treatment)	18.8	25.7
Izapin (treatment + spraying)	16.6	34.4
LSD_{05}	8.0	–

The possibility of use of fertilisers, microelements and growth regulators to increase potato resistance to stem nematode has not been studied in Belarus before. For pre-planting tuber treatment we used boron-copper fertiliser, double superphosphate, $KMnO_4$, H_3BO_3, $CuSO_4$, turf oxidate. Their biological efficacy was in the range of 18.6–56.9% (Table 6).

Autumn greenbelt setting of potato seed tubers had a significant effect on stem nematode display. The biological efficacy of this method was 39.9% (Table 7).

Table 6. The influence of fertilisers, microelements and growth regulators on *D. destructor* infestation on potato tubers

Treatment	Disease incidence %	Biological efficacy %
Control (water)	25.3	–
Prestige (standard)	17.5	30.8
Boron-copper fertiliser	20.5	19.0
Double superphosphate solution	10.9	56.9
$KMnO_4$	20.6	18.6
H_3BO_3	16.3	35.6
$CuSO_4$	14.5	42.7
Turf oxidate	16.9	33.2
LSD_{05}	8.0	–

Table 7. The influence of spring and autumn greenbelt setting on *D. destructor* infestation on tubers

Treatment	Disease incidence %	Biological efficacy %
Control (without greenbelt setting)	25.3	–
Autumn greenbelt setting	15.2	39.9
Spring greenbelt setting	17.9	29.2
LSD_{05}	8.0	–

Conclusions

1. Potato stem nematode is spread unevenly in Belarus. The disease occurs most heavily in Minsk region. Tubers affected by stem nematode were found in 69.7% of all potato lots examined in this region.

2. It was found that the higher level of potato seed tuber infestation results in the higher disease incidence and severity on the new yield tubers, which significantly reduces the crop yield.

3. Under the conditions of Belarus, for the first time the disease was recorded in the form of brown-coloured spots deeply penetrating into the tubers. The deep form of stem nematode on potato was found to be caused by *D. dipsaci*.

4. A 2-hour thermal treatment of potato seed material affected by *D. destructor* at different levels considerably reduced stem nematode infestation on tubers. The use of wet warming at 45 and 50^o C and also dry warming at 50^o C for weakly affected tubers proved to be the most effective for this purpose. In these cases disease severity was not registered.

5. Among the tested biological and chemical preparations, growth regulators and fertilisers, the highest protective effect against *D. destructor* was exhibited by micolin (titre $1*10^8$ kl ml^{-1}, 100 vk/1l of water), nemabact (titre $5*10^6$ nematode/ml, 1 ml/1l of water), double superphosphate solution (4% solution), boric acid (0.5% solution), copper sulfate (0.6% solution), turf oxidate (0.03–0.05% solution), soil treatment with percaltsit (300 g m^{-2}), combined application of izapin (seed treatment + plants spraying during vegetation period, 1 ml l^{-1} of water), and autumn greenbelt setting of seed tubers.

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