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THE EFFECT OF TEMPERATURE, POTATO VARIETIES, AND THE ORIGIN OF CYST ON THE REPRODUCTIVE BIOLOGY OF *Globodera rostochiensis*

PENGARUH SUHU, VARIETAS KENTANG, DAN ASAL SISTA TERHADAP BIOLOGI REPRODUKSI Globodera rostochiensis

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ABSTRACT

Potato cyst nematode (*Globodera rostochiensis* [Wollenweber] Behrens) is a nematode species of worldwide regulatory concern. This nematode caused serious economic of potato losses in Indonesia. This research studied by factorial designed to evaluated the effect of temperature (10, 20, and 30ºC), potato varieties (`Granola´, `Margahayu´, and `Cipanas´), and origin of cyst (West, Central, and East Java) on reproductive biology of *G. rostochiensis* in the growth chamber. The research was conducted by observed of produced the new cyst number, reproduction fitness, survival, fecundity, and multiplication of *G. rostochiensis*. The result showed that all of the potato varieties were infected by *G. rostochiensis* when they were grown at the temperature ranging of 20 and 30ºC but not at 10ºC. The optimum temperature for maximum number of cysts with the highest reproduction factor, survival, fecundity and multiplication rate for all populations was 20ºC. The origin of cyst did not have any effect on the reproductive rate. The temperature of 20ºC provided is best environment for the life of *G. rostochiensis* on Granola.

Keywords**:** *Globodera rostochiensis*, potato variety, reproductive biology, temperature

INTISARI

*Nematoda sista kentang (*Globodera rostochiensis *[Wollenweber] Behrens) adalah spesies nematoda yang mendapatkan perhatian khusus di seluruh dunia.* G. rostochiensis *menyebabkan kerugian ekonomi yang serius pada pertanaman kentang di Indonesia. Penelitian ini menguji pengaruh perbedaan suhu (10, 20, dan 30ºC), varietas kentang (Granola, Cipanas, dan Margahayu), dan asal sista (Jawa Barat, Jawa Tengah, dan Jawa Timur) terhadap biologi reproduksi* G. rostochiensis *di* growth chamber *menggunakan rancangan acak lengkap faktorial. Pengamatan dilakukan terhadap jumlah sista baru, kemampuan reproduksi, daya tahan hidup, keperidian dan multiplikasi* G. rostochiensis. *Seluruh varietas kentang yang diuji terserang* G. rostochiensis *pada suhu 20 dan 30ºC kecuali pada suhu 10ºC. Kisaran suhu optimum untuk memperoleh jumlah sista baru yang maksimum dengan kemampuan reproduksi, daya tahan hidup, keperidian dan multiplikasi untuk semua populasi adalah 20ºC. Asal sista tidak berpengaruh terhadap biologi reproduksi yang diteliti. Kentang varietas Granola yang ditanam pada suhu 20ºC merupakan inang yang sesuai untuk kehidupan* G. rostochiensis.

Kata kunci: biologi reproduksi, *Globodera rostochiensis*, suhu, varietas kentang

INTRODUCTION

Potato cyst nematode (*Globodera rostochiensis* [Wollenweber] Behrens) is the most destructive nematode around the world (Marks & Rojancovski, 1998; Hodda & Cook, 2009). *G. rostochiensis* is a broadly distributed species in tropical and subtropical of the world. As the distribution of seed expands, the distribution of *G. rostochiensis* could expands as well. In Indonesia, *G. rostochiensis* was identified for the first time in the potato-growing area in Malang, East Java, in March 2003 (Indarti *et al.*, 2004).

G. rostochiensis damages potato plantation, thus contributing to low yields and limit the choice of potato cultivars (Oerke, 2006). The most potato varieties planted in Indonesia was Granola, although the Indonesian Vegetables Research Institute (IVegRI) have developed and released two varieties Cipanas and Margahayu. Cipanas was susceptible to *Meloidogyne* sp. (Anonymous, 1980) and Margahayu was well adapted in the highlands with altitude of 1.000−2.000 m above sea level (Anonymous, 2008).

Understanding the response of variety and local environment to *G. rostochiensis* are essential in developing the management of this nematode. The effects of temperature on embryonic development may comprise an important factor in the ecology and distribution of nematode. This temperature

could be an important factor in the overall fitness of the nematode and its ability to extend its distribution range (Noe & Sikora, 1995). Soil temperature during the growing season affected the initial energy reserves of *G. rostochiensis* larvae. Relationships between soil temperatures and the *G. rostochiensis* biology and population multiplication were investigated to understand the risks to potato crops from *G. rostochiensis* in relation to increasing soil temperatures associated with climate change, and to support *G. rostochiensis* management model development. The objectives of this research were to determine the effect of temperature, potato varieties and the origin of cyst on reproductive biology of *G. rostochiensis*.

MATERIALS AND METHODS

Experimental Design

The experiment employed a completely randomized factorial design with three factors and five replications. The first factor was the temperature consisting of three temperatures 10, 20, and 30ºC. The second factor was the origin of *G. rostochiensis* cyst, consisting of Pangalengan (West Java), Wonosobo (Central Java), and Malang (East Java). The third factor was potato varieties Granola, Cipanas, and Margahayu.

Potato Planting and Infestation of G. rostochiensis *Cyst*

Pots (13 cm diameter and 11 cm deep) were filled with a fine steam sterilized soil (particle size of 100−400µm) and sterilized manure with a ratio of 2:1 (w:w). Twenty cyst was put in muslin bags from each population (Pangalengan, Wonosobo, and Malang). Shoot potato seed (Granola, Cipanas, and Margahayu) and cysts were infestated in soil (Salazar & Ritter, 1993). After planting, the pots were placed in growth chambers in the laboratory of *Center for Diagnostic Standard of Agricultural Quarantine*, from September 2014 to August 2015. A thermocouple was placed in the growth chambers and the maximum-minimum temperatures were measured daily. The temperature regimes were 10, 20, and 30ºC with relative humidity of 80%. The light in the growth chamber was set with the illumination intensity of 3.400 lux, 12:12 (L:D) cycle. The plants were watered twice a day. In addition, the plants were fertilized according to the field recommendation.

Reproductive Biologi of Cysts Analysis

The crops harvested at 85 days after planting. The soil was removed from each pot, placed in a plastic tray and then all dried at the temperatures of 22ºC (Tiliikalla, 1992). The roots were carefully washed to remove soil particles. Soil extraction to collect cysts was carried out according to Beaker method (Turner & Evans, 1998).

Observation was conducted by counting cyst number (the number of cysts found outside the muslin bag), reproduction fitness (number of cysts at the end of the study/number of cysts were inoculated), survival (number of cysts developed/ number of eggs added originally), fecundity (eggs/ new cyst), and multiplication (survival × fecundity).

Data Analysis

Analysis of variance (ANOVA) was conducted using SAS Program and mean differences were analyzed using Duncant Multiple Range Test (DMRT) at $\alpha = 5\%$ if *F* test showed significance.

RESULTS AND DISCUSSION

The result showed that development of *G. rostochiensis* was influenced by the temperature and the potato variety (Table 1−5). The potato planted in low temperature (10ºC), the infestated cysts did not grow. The interaction between temperature of 20ºC and tested potato variety significantly affect the biological development of *G. rostochiensis* such as the number of new cysts, reproduction fitness, survival and multiplication of *G. rostochiensis* ($P < 0.05$). On the other hand, high temperature (30ºC) did not interact with potato varieties. The development of *G. rostochiensis* was significantly better at 20ºC

Table 1. The effect of temperature, origin of cyst, and potato varieties on the number of *Globodera rostochiensis* new cysts

Varieties	Temperature (ºC)			Variety	Origin of cysts	
	10	20	30			
Granola	0 d	414.60 a	114.27c	176.290	West Java	139.84
Cipanas	0 d	66.93 cd	116.27c	61.067	Central Java	132.02
Margahayu	0 d	300.60 b	132.67c	144.420	East Java	109.84
Temperature	0	260.71	121.07	(+)		

Means followed by same letter are not significantly different.

Table 2. The effect of temperature, origin of cyst, and potato varieties on reproduction factor of *Globodera rostochiensis*

Varieties	Temperature (ºC)			Variety	Origin of cysts	
	10	20	30			
Granola	0 d	20.730 a	5.677 c	8.80	West Java	6.97
Cipanas	0 d	3.347 cd	5.750 c	3.03	Central Java	6.58
Margahayu	0 d	14.963 b	6.633 c	7.20	East Java	5.48
Temperature	0	13.01	6.02	(+)		

Means followed by same letter are not significantly different.

Table 3. The effect of temperature, origin of cyst, and potato varieties on survival of *Globodera rostochiensis*

Varieties	Temperature (ºC)			Variety	Origin of cysts	
	10	20	30			
Granola	0 d	0.033 a	0.009 c	0.014	West Java	0.011
Cipanas	0 d	0.005 cd	0.009 c	0.005	Central Java	0.011
Margahayu	0 d	0.024 b	0.011 c	0.012	East Java	0.009
Temperature	0	0.021	0.010	(+)		

Means followed by same letter are not significantly different.

Table 4. The effect of temperature, origin of cysts, and potato varieties on fecundity of *Globodera rostochiensis*

Varieties	Temperature (ºC)			Variety	Origin of cysts	
	10	20	30			
Granola	0	458.4	463.2	307.200	West Java	341.600
Cipanas	0	455.07	455.07	303.380	Central Java	310.489
Margahayu	0	458.4	491.67	316.690	East Java	275.178
Temperature	0	457.290	469.980	(-)		

Means followed by same letter are not significantly different.

on all tested potato varieties than at 30ºC. The best development for *G. rostochiensis* was observed when this nematode attacked in Granola at the temperature of 20ºC. In contrast, *G. rostochiensis* had the lowest biological development when they attacked in Cipanas at 20ºC.

Granola, Margahayu, and Cipanas were susceptible potato variety to *G. rostochiensis*. However, *G. rostochiensis* couldnot grow in the susceptible potato variety with unfavorable temperature (10ºC). In addition, there was a growth inhibition when *G. rostochiensis* was reared in the susceptible potato variety with high temperature (30ºC). The origin of the cysts did not affect the development of *G. rostochiensis*. The cyst from West, Central, and East Java produced no significant differences on the development of *G. rostochiensis*.

This research showed that *G. rostochiensis* was not able to grow on the soil temperature of 10ºC, indicated that *G. rostochiensis* was not tolerant to low temperatures. Unfavorable environment (low temperature) resulted dormancy of *G. rostochiensis*. In Finland, *G. rostochiensis* eggs could not hatch at 9ºC (Mulder, 1988). Eggs contained within the cyst will undergo diapause at temperatures less than 5ºC (Salazar & Ritter, 1993). Furthermore, *G. rostochiensis* developed at 20 and 30ºC in Granola, Cipanas, and Margahayu, although they grew better 20ºC. These findings were similar with the previous research showed *G. rostochiensis* grew well in potato at ±20ºC, and the cysts survived in the soil for one year (Ingham *et al.*,2015; Kaczmarek *et al*., 2014; Rinus, 2014; Lisnawita, 2007; Mulyadi *et al*., 2004).

All tested varieties were susceptible to *G. rostochiensis* because the population of cyst was > 100 cysts/plant/pot (Sysoeva, *et al*., 2011). Furthermore, the best temperature for this nematode was 20ºC. Therefore, combination of susceptible potato and suitable temperature have better control at the spread of *G. rostochiensis*. Although at 30ºC, this nematode did not grow as good as at 20ºC, they were able to reproduce. Nematode development at a

Table 5. The effect of temperature, origin of cysts, and potato varieties on multiplication of *Globodera rostochiensis*

Varieties	Temperature (ºC)			Variety	Origin of cysts	
	10	20	30			
Granola	0 d	20.817 a	5.690 c	8.836	West Java	7.008
Cipanas	0 d	3.287 cd	5.723 c	0.003	Central Java	6.590
Margahayu	0 d	15.017 b	6.667 c	7.228	East Java	5.469
Temperature	0	13.040	6.027	(+)		

Means followed by same letter are not significantly different.

high temperature (30ºC) is limited by the inability of the host plant to provide adequate nutrition for the development of *G. rostochiensis* because of the growth of the host plant was not optimum (Kaczmarek *et al*., 2014). In Southern Italy, second stage larva of *G. rostochiensis* decreased drastically invasion into the roots at a temperature of more than 25ºC and 95% reduction occurred in a population of *G. rostochiensis* at temperature more than 30ºC (Bacic *et al.*, 2011; Bridge & Starr, 2010; Turner & Evans, 1998). This suggests that increasing temperature due to external factors may be coped by the adaptability of this nematode. If this happens, more serious damage of potato by this nematode is predicted in the future.

CONCLUSION

Globodera rostochiensis grew well in all tested varieties (Granola, Cipanas, and Margahayu) when they lived at the temperature 20 and 30ºC. Temperature of 20ºC provided the better environment than 30ºC. Granola grown at 20ºC was the best host for *G. rostochiensis*.

LITERATURE CITED

Anonymous. 1980. Keputusan Menteri Pertanian Nomor: 154/Kpts/Um/4/1980, Tanggal: 10 Maret 1980 tentang Deskripsi Kentang Varietas Cipanas.

Anonymous. 2008. Keputusan Menteri Pertanian Nomor: 447/Kpts/SR.120/4/2008, Tanggal: 22 April 2008 tentang Deskripsi Kentang Varietas Margahayu.

Bacic J, P. Barsi, & P. Strbac. 2011. Life Cycle of the Potato Golden Cyst Nematode (*Globodera rostochiensis*) Grown under Climatic Conditions in Belgrade. *Archives of Biological Sciences* 63: 1069−1075.

Bridge, J. & J. L. Starr. 2010. *Plant Nematodes of Agricultural Importance*. Academic Press, Boston. 152 p.

Hodda, M. & D.C. Cook, 2009. Economic Impact from Unrestricted Spread of Potato Cyst Nematodes in Australia. *Phytopathology* 99: 1387–1393.

Indarti, S., Bambang, R.T.P., D. Mulyadi & B. Triman. 2004. First Record of Potato Cyst Nematode *Globodera rostochiensis* in Indonesia. *Australasian Plant Pathology* 33: 325−326.

Ingham, R.E., D. Kroese, & .A. Zasada. 2015. Effect of Storage Environment on Hatching of the Cyst Nematode *Globodera ellingtonae*. *Journal of Nematology* 47: 45–51.

Kaczmarek, A., K. Mac Kenzie, H. Kettle, & V.C. Blok. 2014. Influence of Soil Temperature on *Globodera rostochiensis* and *Globodera pallida*. *Phytopathologia Mediterranea*. 53: 396−405.

Lisnawita. 2007. Identifikasi, Kajian Biologi dan Ketahanan Tanaman terhadap Nematoda Sista Kentang (*Globodera* spp.) Indonesia. Disertasi. Sekolah Pascasarjana Institut Pertanian Bogor, Bogor. 110 p.

Marks, R. J. & Rojancovski. 1998. Potato Cyst Nematodes (*Globodera* species) in Central Europe, the Balkans and the Baltic States, p. 299−315. *In* R.J. Marks & B.B. Brodie (eds.), *Potato Cyst Nematodes: Biology, Distribution and Control*. CAB International, Oxon.

Mulder, H. 1988. Temperature Response of *G. rostochiensis* Woll. and *G. pallida* Stone. *Nematologia Mediterranea* 45: 434–440.

Mulyadi, B. Rahayu, B. Triman & S. Indarti. 2004. Studi Bioekologi Nematoda Sista Kuning (*Globodera rostochiensis*). Kerja sama antara Balai Penelitian Sayuran Lembang Bandung dengan Fakultas Pertanian Universitas Gadjah Mada, Yogyakarta. Laporan Penelitian. 20 p.

Noe, J.P. & R.A. Sikora. 1995. Efek Iklim Tropik pada Distribusi dan Hubungan Inang-Parasit pada Nematoda Parasitik Tumbuhan, p. 786−789. *In* M. Luc, R.A. Sikora, & J. Bridge (eds.), *Nematoda Parasitik Tumbuhan di Pertanian Subtropik dan Tropik*. Gadjah Mada University Press, Yogyakarta.

Oerke E.C. 2006. Crop Losses to Pests. *Journal of Agricultural Science* 144: 31–43.

Rinus, K. 2014. A Molecular, Morphological and Biological Characterisation of the Genus *Globodera* (Nematoda: Heteroderinae) in South Africa. Dissertation: Agricultural Sciences at the University of Stellenbosch, Stellenbosch. 284 p.

Salazar & E.J.Ritter. 1993. Effects of Daylength during Cyst Formation, Storage Time and Temperature of Cysts on the *In vitro* Hatching of *Globodera rostochiensis* and *G. pallida. Fundamental and Applied Nematology* 16: 567−572.

Sysoeva, M,I., V. V. Lavrova, E.M. Matveeva, E.G. Sherudilo, & L.V. Topchieva. 2011. Cross Adaptation of Potato Plants to Low Temperatures and Potato Cyst Nematode Infestation. *Russian Journal of Plant Physiology* 58: 999–1004.

Tiilikkala, K.A. 1992. Influence of Soil Temperature on Initial Energy Reserves of *Globodera rostochiensis* larvae. *Fundamental* and *Applied Nematology* 15: 49−54.

Turner, S. & K. Evans, 1998. The Origin, Global Distribution and Biology of Potato Cyst Nematodes (*Globodera rostochiensis* Woll and *G. pallida* Stone), p. 7−23. *In* R.Y. Marks & B.B. Brodie (eds.),*Potato Cyst Nematodes, Biology, Distribution and Control*. *CAB International*, Wollingford, UK.