THE EFFECT OF TEMPERATURE, POTATO VARIETIES, AND THE ORIGIN OF CYST ON THE REPRODUCTIVE BIOLOGY OF \textit{Globodera rostochiensis}

\textbf{PENGARUH SUHU, VARIETAS KENTANG, DAN ASAL SISTA TERHADAP BIOLOGI REPRODUKSI Globodera rostochiensis}

Nurjanah\(^1\)*, Y. Andi Trisyono\(^2\), Siwi Indarti\(^2\), & Sedyo Hartono\(^2\)

\(^1\)Center for Diagnostic Standard of Agricultural Quarantine
\(^2\)Department of Crop Protection, Faculty of Agriculture, Universitas Gadjah Mada

*Corresponding author. E-mail: dedenurj4n4h@gmail.com

\section*{ABSTRACT}

Potato cyst nematode (\textit{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 30\(^{\circ}\)C), potato varieties (`Granola’, ‘Margahayu’, and ‘Cipanas’), and origin of cyst (West, Central, and East Java) on reproductive biology of \textit{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 \textit{G. rostochiensis}. The result showed that all of the potato varieties were infected by \textit{G. rostochiensis} when they were grown at the temperature ranging of 20 and 30\(^{\circ}\)C but not at 10\(^{\circ}\)C. The optimum temperature for maximum number of cysts with the highest reproduction factor, survival, fecundity and multiplication rate for all populations was 20\(^{\circ}\)C. The origin of cyst did not have any effect on the reproductive rate. The temperature of 20\(^{\circ}\)C provided is best environment for the life of \textit{G. rostochiensis} on Granola.

Keywords: \textit{Globodera rostochiensis}, potato variety, reproductive biology, temperature

\section*{INTRODUCTION}

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

\textit{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 is susceptible to \textit{Meloidogyne} sp. (Anonymous, 1980) and Margahayu is 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 \textit{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 of potato to be attacked by *G. rostochiensis* in relation to increasing soil temperatures associated with climate change, and to support the development of management model of *G. rostochiensis*. 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, from Pangalengan (West Java), Wonosobo (Central Java), and Malang (East Java). The third factor was potato varieties, i.e. 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 of potato seed (Granola, Cipanas, and Margahayu) and cysts were placed 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 Biology of Cysts**

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 Duncan Multiple Range Test (DMRT) at α = 5% if *F* test showed significance.

**RESULTS AND DISCUSSION**

The result showed that development of *G. rostochiensis* was influenced by the temperature and potato variety (Table 1−5). The cysts did not grow on potato planted in low temperature (10ºC). The interaction between temperature of 20ºC and potato variety significantly affected 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 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,

| 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 |

Means followed by same letter are not significantly different.
G. rostochiensis had the lowest biological development on Cipanas variety at 20ºC. Granola, Margahayu, and Cipanas were susceptible potato variety to G. rostochiensis. However, G. rostochiensis could not grow in the susceptible potato variety with unfavorable temperature (10ºC). In addition, there was a growth inhibition when G. rostochiensis reared in susceptible 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 could not grow on the soil with temperature of 10ºC, indicated that G. rostochiensis was not tolerant to low temperatures. Unfavorable environment (low temperature) trigger the dormancy of G. rostochiensis. In Finland, G. rostochiensis eggs could not hatch at 9ºC (Mulder, 1988). Eggs 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 at 20ºC. These findings were similar with the previous research which showed that 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 still able to reproduce. Nematode development at a 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

---

### 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         | 6.97 West Java |
| Cipanas   | 0 d             | 3.347 cd| 5.750 c         | 6.58 Central Java |
| Margahayu | 0 d             | 14.963 b| 6.633 c         | 5.48 East Java |

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 |
| Cipanas   | 0 d             | 0.005 cd| 0.009 c         | 0.005 Central Java |
| Margahayu | 0 d             | 0.024 b | 0.011 c         | 0.012 East Java |

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 |
| Cipanas   | 0               | 455.07  | 455.07          | 303.380 Central Java |
| Margahayu | 0               | 458.4   | 491.67          | 316.690 East Java |

Temperature 0 457.290 469.980 (-)

Means followed by same letter are not significantly different.
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: 396–405.

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.

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

Means followed by same letter are not significantly different.

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

Tiilikala, 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, Wallingford, UK.