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Distribution and Infestation of Yellow Cyst Nematodes on Potato Farm Area in Malang District, Indonesia

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Abstract | One of the obstacles that can reduce the productivity of potato plants (*Solanum tuberosum* L.) is the presence of pest and disease attacks. One of the critical diseases is Yellow Cyst Nematode - YCN (*Globodera rostochiensis* Wollenweber, 1923). YCN are microscopic, worm-shaped pests that feed on the roots of potatoes, tomatoes, eggplants, and other plants of the Solanaceae family. Root damage causes plants to become stunted; flowering is delayed, leaves turn yellow, wilt, and the plant dies. YCN is the main parasite known to attack potato plants in Indonesia in early 2003. When it attacks potato plants, the plants can still produce, but the tubers produced are small and few. The research aimed to determine the distribution of YCN in the potato planting area of the Pujon sub-district and the Poncokusumo sub-district, Malang district, as well as the potato planting area of the Bumiaji sub-district, Batu City. Further objectives are to support the Sustainable Development Goals (SDGs), especially the Goal 2: Zero hunger, and the Goal 3: Good health and well-being. Destructive soil sampling was conducted in potato fields and observed in the laboratory. The results show that the Pujon sub-district had no YCN population. In contrast, the potato fields in the Poncokusumo sub-district and Bumiaji sub-district had a YCN population, but in the light category, namely 0.8×10^2 eggs g^{-1} of soil, and very light, namely 0.075×10^2 juveniles g^{-1} of soil.

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Introduction

Potatoes (*Solanum tuberosum* L.) are a commodity as source of protein-rich carbohydrates and as a support for food diversification (Setyobudi *et al*., 2024a). The growing development of the snack food industry and fast food restaurants, which is one of the raw materials for potatoes, has increased the demand for potato products that are safe for consumption (Diwa *et al*., 2015; Kalimullin *et al*., 2019; Setyobudi *et al*., 2024b). So the potato commodity gets priority for development because it is a source of non-rice carbohydrates and has the potential for food diversification programs (Mustafa *et al*., 2019; Setyobudi *et al*., 2024a). According BPS data (Kurnia, 2023). Indonesian potato production has increased gradually since 2021, peaking in April 2022. However, production decreased again in 2020. After that, production began to increase again in 2021 and reached peak production in April 2022 (Kurnia, 2023).

One of the risk factors in potato farming from the field to storage is the potato cyst nematode or in some literature the yellow cyst nematode - YCN (*Globodera rostochiensis* Wollenweber, 1923) another common name: Golden nematode and golden eelworm (Indrawan *et al*., 2021; Jiang *et al*., 2025). Symptoms of potatoes attacked by YCN are characterized by a decrease in production reaching 70 %, from normal production of 25 t ha^{-1}, down to 10 t ha^{-1} (Yusianto and Marimin, 2024). Potato plants attacked by YCN can still survive, but the tubers produced are few in number and small in size so they can be detrimental to farmers. The potential loss of potato yields due to YCN attacks can reach 80 % (Selamet *et al*., 2019; Widjaja and Hadisoeganda, 2006). YCN is a microscopic worm that feeds on the roots of potatoes (*S. tuberosum*), tomatoes (*Solanum lycopersicum* L.), eggplants (*Solanum melongena* L.) and other plants of the Solanaceae family (Fadilah *et al*., 2022; Rahmadhini *et al*., 2023). Mechanically, YCN damages plant tissue, chemically secretes enzymes so that it can influence pathological changes in host cells (Wahyuni, 2020).

Root parasitic nematodes can spread via contaminated tubers, necessitating to mapping of critical infestation zone. The data on the abundance of these parasites is needed for nematode management in the field, especially potato centers which are centers that supply potato tuber seeds to other potato production centers throughout Indonesia (Husen *et al*., 2023). The aim of the research was analyzing nematode populations and their possible distribution in three potato production center locations in Malang Regency, East Java, Indonesia. Further objectives are to support the Sustainable Development Goals (SDGs), especially the Goal 2: Zero hunger, and the Goal 3: Good health and well-being.

Materials and Methods

The research was carried out in the potato planting fields belonging to farmers in Pujon subdistrict, Poncokusumo subdistrict, Malang district and Bumiaji Batu subdistrict. Since the target of the research is the potato planting area. Soil analysis was carried out in the soil laboratory of the Food Crops and Horticulture Agribusiness Development UPT Bedali, Lawang, Malang.

Statistical method using a randomized block design with analysis of variance. If the results of the analysis of variance show differences, a 5 % Duncan test is then carried out, to compare the differences locations (Setyobudi *et al*., 2024c). The observed data from each fields is zero (there is no YCN population), before being analyzed, the data was transformed first to $\sqrt{(x+0.5)}$ (Damat *et al*., 2020).

Soil sampling

Soil from each sub-district of Pujon, Poncokusumo, Malang district and Bumiaji Baru sub-district, five soil samples were taken using the diagonal intersection method. Soil was collected from the rhizosphere (10 cm to 30 cm depth) at five zig-zag points per field. The soil was taken to the laboratory to be observed in the presence of YCN. A total of 250 g of soil samples was taken at a depth of 10 cm to 30 cm (plant root area) and mixed with the root parts. The soil was taken to the laboratory to be observed in the presence of YCN.

Observation of YCN populations

Based on Astuti and Ruslan (2019) that nematode populations can be calculated using various isolation-extraction techniques, namely the isolation extraction technique using a Baermann funnel, the white head tray (soil) method, the centrifuge method, the misting method and the filter method.

However, in this study, the filter method was used, namely the soil sample was weighed and dissolved in distilled water, left for 1 h to 2 h, then filtered using a predetermined size filter. Extraction of nematode cysts was carried out using the Baermann funnel method, namely by weighing 100 g of soil samples from each point. Samples were transferred to glass beaker (Muhammad and Ibrahim, 2021).

Nematodes were isolated via serial filtration [(150, 250, and 500) mesh sieves], followed by a sedimentation-decantation process 6 to 8 times or until clean nematodes are obtained from the media (Dimas, 2024; Duma *et al*., 2024; Yusinta and Gafur, 2020). Then the sample was soaked in 1 L of water and stirred until homogeneous. The sample that has been stirred is left for approximately 1 h to 2 h, so that the water collected is clear because the soil sediment has dropped to the bottom and leaves the cyst floating on the edge of the surface of the glass beaker. The number of cysts from each field was then calculated. The nematode population was calculated by pouring the extracted suspension into a cyracus cup and then observing it under a stereo and compound microscope with a magnification of 10 × 10.

Analysis of soil nutrient content

Chemical content, namely soil nutrients, includes N, P and K content, as well as soil organic matter. The physical condition of the soil includes the structure and texture of the soil.

Weather data collection

Weather data obtained from the Malang Regency Meteorology, Climatology and Geophysics Agency includes: daily temperature, rainfall, light intensity, humidity and duration of exposure.

Results and Discussion

Yellow cyst nematode population

The results of the study showed that five locations of potato planting areas in Pujon sub-district were not infested with YCN, while in Poncokusumo sub-district and Bumiaji Batu sub-district there were several locations infested with YCN. The results of observations in the potato planting area in the Poncokusumo sub-district only found two location among the five potato planting areas observed to have a population of YCN. The results of observations of the are presented in Table 1.

The data displayed is the average of observation results (not yet transformed). * Before analysis the data is transformed in √(x + 0.5).

In Table 1, it appears that the results of the analysis of the variety of YCN populations show that there are significant differences in the potato planting area in Poncokusumo subdistrict, Malang district, while the YCN population in the potato planting area in Bumiaji subdistrict does not show a significant difference (p= 0.05). In potato planting areas in the Bumiaji sub-district, farmers tend to use pesticides, while the bodies of nematodes are very fragile so the population obtained is in the egg phase. The results of observations of the YCN population did not show a juvenile phase, nor did they occur in the potato planting area in Poncokusumo sub-district. Based on the opinion of (Astuti and Ruslan, 2019; Duma *et al*., 2024; Muhammad and Ibrahim, 2021; Yusinta and Gafur, 2020), the intensity of cyst attacks in potato planting areas in Bumiaji Batu sub-district is in the light category, potato planting in Poncokusumo sub-district is in the very light category.

Table 1: *Average yellow cyst nematode population in potato planting areas in Malang district (10^2 g^{-1} of soil).*

Location	Yellow cyst nematode population (10^2 g^{-1} soil)*		
	Pujon	**Bumiaji**	**Poncokusumo**
A	0	0.25 a	0.125 b
B	0	1.25 a	0 a
C	0	1.75 a	0 a
D	0	0.50 a	0 a
E	0	0.25 a	0.25 b

Notes: numbers followed by the same letter in the same column are not significantly different (p = 0.05) based on the Duncan 5 % test.

Cimate data during the research

Climate data during the research was taken from agency for meteorology, climatology and geophysics (BMKG) Malang district. Climatic data includes: daily average temperature, radiation intensity, rainfall intensity, relative humidity, and day length as presented in Table 2.

Table 2: *Average climate data (temperature, relative humidity, rainfall, and duration of irradiation) for September, October and November 2024.*

Indicator	September	October	November
Temperature (°C)	26.3	25.6	24.3
Relative humidity (%)	76.7	80.8	85.9
Rainfall (mm)	2.8	33.7	145.8
Duration of irradiation (h)	6.5	6.9	5.0

Notes: data obtained from BMKG Malang district

Based on Table 2, it appears that humidity and rainfall intensity are higher in November, and the duration of exposure/intensity of exposure is increasingly lower. There is no difference in the average daily temperature from September to November 2024 because the average potato planting location is more than 1 000 m above sea level (m.a.s.l.). The potato plants area in Pujon sub-district is 1 200 m.a.s.l., the potato planting area in Bumiaji Batu sub-district is 1 084 m.a.s.l., and the potato planting area in the Poncokusumo sub-district is 1 400 m.a.s.l.

Dimas (2024) stated that temperature influences the development of the *G. rostochiensis* species, where abiotic factors from the environment that are very important in influencing the YCN population are temperature. Furthermore, it was also stated that YCN can survive for approximately 30 yr in the soil, but this situation depends on the environmental conditions in the potato planting area where YCN manifests (Astuti and Ruslan, 2019; Muhammad and Ibrahim, 2021). The development of YCN is influenced by temperature. If environmental conditions are not conducive to the life of YCN, the worm eggs will go into dormancy. When conditions permit, the egg hatches to fulfill its life cycle. The soil temperature required for *G. rostochiensis* eggs to hatch is 15 °C to 20 °C, while the eggs of the nematode *G. pallida* require a lower temperature than the *G. rostochiensis* species (Adomako *et al.*, 2022; Amritha and Budijastuti, 2018).

Apart from that, the spread of YCN can occur through the seeds used by farmers. Potato seeds contaminated with YCN will spread from one field to another (Husen *et al.*, 2023). Furthermore Adomako *et al.* (2022) stated that YCN species that have been infested with land, result in nematodes remaining on the land and it is impossible to be free from YCN.

Soil nutrient content

The results of the analysis of the soil nutritional content of each potato planting area in Pujon sub-district, Poncokusumo sub-district and Bumiaji Batu sub-district are presented in Table 3.

Table 3 show organic N content (0.11 % to 0.20 %) across all sites, with Pujon field having lowest phosphorus level (5.0 mg kg^{-1} to 10.0 mg kg^{-1}), Bumiaji and Poncokusumo fields are having medium level (11.0 mg kg^{-1} to 15.0 mg kg^{-1}). The potassium content of Pujon field having highest level (> 1.0 me), while Bumiaji and Poncokusumo are low (0.1 me to 0.3 me).

Table 3: *Soil nutrient content in each potato planting area (Pujon sub-district, Poncokusumo sub-district, Malang district, and Bumiaji Batu sub-district).*

Indicator	Soil nutrient content		
	Pujon	**Bumiaji**	**Poncokusumo**
N organic (%)	0.13*	0.103*	0.104*
P_2O_5 (mg kg^{-1})	5.39*	15.71**	13.41**
K (me)	2.52***	0.28*	0.18*
Texture	dusty loam	dusty clay loam	dusty clay
pH	6.5	6.7	6.6

*Notes: *low; **currently; ***very high (Prasetyo et al., 2022).*

YCN are able to survive in the soil depending on the environmental conditions in the land where YCN manifests, including soil temperature and soil type (Duma *et al.*, 2024; Yusinta and Gafur, 2020). Furthermore stated that the type of soil that influences how YCN can survive in the soil is sandy loam (Adomako *et al.*, 2022; Amritha and Budijastuti, 2018; Dimas, 2024). This type of sandy loam soil has a higher composition of sand than dust and clay. This type of soil causes the movement of nematodes in the soil more easily compared to clay soil with a higher dust composition (Lestari *et al.*, 2024a, b). The soil in the survey area is andosol soil with the criteria of dusty clay (Pujon sub-district), dusty clay loam (Bumiaji sub-district), and dusty clay (Poncokusumo sub-district). For this reason, the results of isolation and identification show that the intensity of YCN attacks is in the category of very light to non-existent (Table 1).

The soil type criteria in the Bumiaji sub-district potato planting area really supports the life of YCN because the movement of YCN through water pathways in the soil pores. Adomako *et al.* (2022), Amritha and Budijastuti (2018) stated that soil type greatly influences nematode populations, especially egg hatching. The type of soil with the highest egg hatching was 60 % in sandy soil, while 32 % hatched in mud, clay and swamp soil. It was further stated that soil texture influences soil pore size and water holding capacity (Indratmi *et al.*, 2024; Roeswitawati *et al.*, 2021a, b, 2023). The population level of *G. rostochiensis* can also be influenced by soil temperature, the type of seeds used, the way farmers treat the soil before planting and after planting, soil pH, and the type of soil on agricultural land (Dimas, 2024; Husen *et al.*, 2023; Rahmadhini *et al.*, 2023; Roeswitawati *et al.*, 2024).

Figure 1: *Potato plants whose soil is infected with YCN have yellowing leaves (A) and small tubers (B).*

In Figure 1, it can be seen that the potato plants show symptoms of YCN disease, namely the leaves look uneven yellowing (A). Potato plants attacked by YCN can still survive, but the tubers produced are few in number and small in size (B) so they can be detrimental to farmers. Plant parasitic nematodes are one type of important pest that shows disease symptoms, because they cause major losses to plants in agricultural production systems in tropical and sub-tropical areas (Duma *et al*., 2024). The resulting losses can reach 20 % to 25 %, sometimes even causing the failure of the entire crop (Amritha and Budijastuti, 2018; Dimas, 2024). Nematode attacks result in a reduction in normal root function, resulting in reduced transport of nutrients to the plant tissue above the ground surface (Adomako *et al*., 2022).

Nematode attacks can cause damage to the roots, especially the tissue vessels. The nematodes will suck root cells which disrupt the tissue vessels, thereby hampering the translocation of water and nutrients (Miaomiao *et al*., 2023). Mechanically, nematodes pierce plant tissue using their styles to suck fluids from inside the cells (Johanis, 2021; Tanjung *et al*., 2022). Chemically, nematodes secrete enzymes that can disrupt the pathology of host cells. Infection by the potato cyst nematode causes a variety of symptoms on host plant structures above and below the soil surface (Roeswitawati *et al*., 2021c, 2022).

The potato variety used by farmers in the Batu area is the Granola Kembang potato variety, which is a superior potato variety and is a type of deviation from the Granola Kembang potato variety (Husen *et al*., 2023; Roeswitawati *et al*., 2024; Setyobudi *et al*., 2024a). The Granola Kembang potato variety has advantages compared to other varieties, namely high productivity, round-oval tuber shape, yellow tuber flesh color and shallow tuber eyes (Husen *et al*., 2023; Setyobudi *et al*., 2024b). According to (Husen *et al*., 2023; Roeswitawati *et al*., 2024), Granola variety potatoes are susceptible to YCN attached to their roots. So the Granola Kembang variety was developed which is more resistant to pests and diseases, especially against YCN. The research results of (Roeswitawati *et al*., 2024) showed that the Granola Kembang variety potato which was given bamboo root extract as a plant growth promoting rhizobacterium was able to suppress the development of the pathogen *Phytophthora* sp. causes potato leaf blight.

Nematode attacks can be anticipated before they cause greater losses, so preventive measures need to be taken (Duma *et al*., 2024; Husen *et al*., 2023; Ulfah *et al*., 2012). In the context of preventive measures, information about various nematode species and populations in an area is a very important factor. One of the steps that need to be taken to reduce the risk of damage and loss due to nematodes is to control money appropriately. In order for control to be effective on targets and techniques, information is needed regarding the density and diversity of nematodes in a field (Husen *et al*., 2023; Roeswitawati *et al*. 2024).

Conclusions and Recommendations

Based on the research results, it can be concluded that no yellow cyst nematodes were found in the potato planting area in Pujon sub-district, juvenile phase yellow cyst nematodes were found in the potato planting area in Poncokusumo sub-district, Malang district, and egg-phase yellow cyst nematodes were found in the potato planting area in Bumiaji Batu sub-district. Distribution of YCN, the potato planting area in Pujon sub-district does not have a YCN population, while the potato planting area in Poncokusumo sub-district and Bumiaji sub-district has a YCN population, but in the light category, namely 0.8×10^2 eggs g^{-1} of soil, and very light, namely 0.075×10^2 juveniles g^{-1} of soil. To prevent YCN disease attacks in potato planting areas, it is recommended to use YCN disease-resistant varieties or use seeds from certified breeders.

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Novelty Statement

The first YCN attack in Indonesia was reported in Tulungrejo village, Bumiaji sub-district, Batu City, East Java, in 2003. The nematode, which is endemic to potato plants in Europe has now spread throughout the central potato cultivation areas in Java, Indonesia, especially in Dieng Plateau - Central Java (Dani *et al*., 2018; Slamet *et al*., 2019) and the largest central potato cultivation area in East Java, namely in Plateau Bromo, Probolinggo Regency (Utari, 2016). Novelty reported in this manuscript that one of the potato cultivation centers in East Java, namely Pujon, Malang Regency, was found to be free from YCN. This finding is important because, in Pujon, there are two certified potato breeders, so YCN contamination in this area must be strictly controlled..

Author's Contribution

Dyah Roeswitawati: Conceptualized and designed the study, elaborated on the intellectual content, performed a literature search, and prepared the manuscript.
Syarif Husen: Research supervision, material research, and elaborate the intellectual content
Anik Ariany, Muslih Anwar, and Shazma Anwar: Performed literature search and manuscript review.
Praptiningsih Gamawati Adinurani: Statistical analysis.

All authors have read and approved the final manuscript.

Generative AI and AI-assisted technology statement
The authors stated that they didn't use generative AI and AI-assisted technology in preparing this manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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