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THE LEVEL OF DAMAGE AND THE IDENTIFICATION OF MELOIDOGYNE SPP. FROM MAHANG BARU VILLAGE, HULU SUNGAI TENGAH, SOUTH KALIMANTAN

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ABSTRACT
This study was conducted to address the lack of information regarding celery crop damage in South Kalimantan due to Root Knot Nematode (RKN). This study is critical for determining the extent of celery plant damage caused by RKN (Meloidogyne spp.) in numerous districts/cities in South Kalimantan and identifying the *Meloidogyne* species discovered. The purposive sampling of celery crop infected with RKN was conducted in one city and three districts in South Kalimantan. Sampling was conducted at Sukamaju Ujung village, Landasan Ulin Utara, Banjarbaru City; Mandiangin village, Banjar Regency; Hamak Village, Telaga Langsat District, Hulu Sungai Selatan Regency and Jamil, Banyu Jaranih and Mahang Baru Villages, Labuan Amas Selatan District, Hulu Sungai Tengah Regency. The result showed that RKN were discovered in the Sukamaju Ujung and Mahang Baru villages. Sukamaju Ujung was the most heavily attacked by RKN, with high damage levels ranging from 85-90%, a high galling index of 8-9, and the greatest population of 1282 nematodes/5 grams of roots. In Mahang Baru village, RKN was found to have a damage level of only 15% but a high galling index of 8 (eight) and population of 1049 nematodes/5 grams of roots. Based on the perineal pattern of adult females, three species of *Meloidogyne* were found in Mahang Baru village, namely *M. javanica*, *M. incognita*, and *M. arenaria*. These three species had previously been found in Sukamaju Ujung village.

KEY WORDS
Meloidogyne spp, level of damage, identification, celery.

Celery plants (*Apium graveolens*) continue to be affected by Root Knot Nematodes (RKN) caused by *Meloidogyne* spp. infection in various celery planting areas in South Kalimantan, particularly in Landasan Ulin Utara Village, Banjarbaru City, South Kalimantan, Indonesia. Symptoms in the form of stunted and wilted growth of celery plants, especially during the day and typical symptoms in the form of roots with nodules, often called galls, will ultimately affect the productivity of celery cultivation. The incidence of RKN disease on celery reaches 65%, resulting in low yields (Kurniawati *et al.* 2017). The extent of damage caused by RKN on celery in South Kalimantan is currently unknown. Differences in cultivation methods are thought to affect the intensity of the RKN attack. Kurniawati *et al*. (2017) identified three *Meloidogyne* species that infect celery plants in Ciputri Village, Pacet District, Cianjur Regency, West Java Province: *M. arenaria*, *M. incognita*, and *M. javanica*. They also discovered that the three *Meloidogyne* species were identical, as was one additional species, *M. hapla*, in the villages of Cikole, Cihideung, and Ciputri in Bandung, West Java (Kurniawati *et al.,* 2020). Balkan *et al*. (2019) also discovered *M. incognita* and *M. javanica* in celery planting areas in Samarinda, East

Kalimantan. Three *Meloidogyne* species, *M. arenaria*, *M. incognita*, and *M. javanica*, have been discovered in Sukamara Village, Sukamaju Ujung Village, and Kurnia Village, South Kalimantan Indonesia (Fitriyanti & Noor Aidawati, 2022).

This indicates that in the future, these three species have the potential to spread to celery plants and other plants, considering that *Meloidogyne* has an extensive host range. The whereabouts of celery and the other four regions in South Kalimantan have yet to be discovered.

MATERIALS AND METHODS OF RESEARCH

Sampling was conducted at various locations, including Sukamaju Ujung village, Landasan Ulin Utara, Banjarbaru City; West Mandiangin Village, Banjar Regency; Hamak Village, Telaga Langsat District, Hulu Sungai Selatan Regency; and Jamil village, Banyu Jaranih village and Mahang Baru village, Labuan Amas Selatan District, Hulu Sungai Tengah Regency. Samples were taken using a purposive sampling method with a diagonal system of 10 sample points. Samples were selected from celery plants that showed typical symptoms of infection by RKN, such as a yellowing of the crown leaves on the top surface of the soil, stunted plants, stunted growth, and the presence of root galls. One to three villages were chosen. In each village, one to three sampling locations were taken (adjusted to the survey results). The number of sample points in each village was taken at 10% of the number of farmers' land growing celery. Disease severity was calculated based on Jiang *et al*., (2018) as following:

$$\text{Disease severity} = \left[\sum \frac{\text{the number of root – knot disease plants in this index} \times \text{disease index}}{\text{total plants investigated} \times \text{highest root – knot diseaseindex}}\right] \times 100\%$$

The gall indices were assessed by using methods described by Bridge and Page (1980) as shown below:

Galling index system (0-10)	Percentage of total root system galled	Explanation of rating
0	0	Complete and healthy root system, no infection
1	10	Very few small galls can only be detected upon close examination
2	20	Small galls/knot only but clearly visible main root clean
3	30	Some larger knot visible, main root clean
4	40	Larger knot predominate but main root clean
5	50	50% of root infested, knotting on some main roots, reduced root system
6	60	Knotting on main roots
7	70	Majority of main roots knotted
8	80	All main roots, including tap root, knotted, and few clean root visible
9	90	All roots severely knotted, and plant usually dying
10	100	All roots severely knotted, no root system, and plants usually dead.

The procedure for preparing the perineal pattern analysis refers to Gilchrist-Saavedra *et al*. (1997). Root samples were washed to remove adhering soil particles. The female nematodes in the galled tissue were slowly removed using a needle. The posterior end cut off with an optical scalpel and then the body tissues are slowly removed by lightly brushing the inner surface of the cuticle with a slightly flexible bristle. When all tissues are removed, the posterior part was placed in a lactophenol blue solution containing 0.03% cotton blue and left to soak for ± 24 hours. The posterior part was then carefully trimmed so as to be only slightly larger than the perineal pattern and then transferred to an object glass and added with a drop of blue lactophenol solution. A cover glass was placed on top, sealed with nail polish, and observed using a light microscope with 400x magnification. Nematode identification was carried out by comparing the perineal patterns obtained from each sample with the patterns contained in the

key identification guidebook for the four main *Meloidogyne* species (Eisenback *et al*., 1981). Nematode stage of *Meloidogyne* spp. in plant tissue was observed by staining the purified root tissue (Zuckerman *et al*., 1985). Observation and morphological characterization of the nematode stages found in root tissue were observed using a light microscope, similar to the identification process for female nematodes.

RESULTS OF STUDY

Based on an initial survey several districts with quite large celery plantings were obtained, namely Banjarbaru City (Jalan Sukamaju Ujung, Kel. Landasan Ulin Utara), Banjar Regency (West Mandiangin Village, Karang Intan District), Village Hamak (Telaga Langsat District, Hulu Sungai Selatan Regency), Jamil Village, Banyu Jaranih Village, and Mahang Baru Village (Labuan Amas Selatan District, Hulu Sungai Tengah Regency). Sukamaju Ujung exhibits the most severe damage to plants infected with Root Knot Nematodes (RKN), with an intensity ranging from 85% to 90%. In other districts, RKN attacks were only found in Mahang Village, Kec: Labuan Amas Selatan, Hulu Sungai Tengah, with an attack rate of 15%. The galling index and RKN population in roots and plant tissues are presented in Tables 1-2.

Table 1 – Population of *Meloidogyne* spp. nematodes on celery plant roots

Sample Code	Population of Nematoda (5 g of roots) *Meloidogyne* spp.							
	Egg	J1	J2	J3	J4	Female	Male	Total Population
MB	807	7	14	18	13	189	1	1049
SMU 1	24	3	16	10	13	51	0	117
SMU 2	73	224	22	4	11	58	0	392
SMU 3	915	158	18	18	15	156	0	1280

Note: MB = Mahang Baru, SMU = Sukamaju Ujung, J1 = Juvenil 1, J2 = Juvenil 2, J3 = Juvenil 3, J4 = Juvenil 4.

Table 2 – Galling index of *Meloidogyne* spp. nematodes on celery plant roots

No	Sample Code	Scoring Average
1	MB 1	8
2	SMU 1	8
3	SMU 2	9
4	SMU 3	8

Note: MB = Mahang Baru, SMU = Sukamaju Ujung.

Tables 1-2 indicate that Sukamaju Ujung experienced a significant attack with high intensity, resulting in the greatest total population of 1280 nematodes per 5 grams of roots. This attack also led to a high galling index, with 80-90% of the total root system being affected in the three sample locations, ranging from 8 - 9. The frequency of attacks in Mahang Baru Village was low that was 15%. However, it was accompanied by a high galling index of 8 - 9 and a total population of 1049 per 5 grams of roots. This should be monitored closely since it has the potential to lead to a more extensive transmission.

M. javanica has a special characteristic in the form of two very clear lateral lines that separate the dorsal and ventral striae (Figure 1a). A high and narrow dorsal arch characterizes the perineal pattern of *M. incognita*, while on the outside, it is slightly wider and somewhat flat; the striae pattern looks rough and wavy and has no lateral lines (Figure 1b). *M. arenaria* has a low, slender dorsal arch around the lateral line, the branching striae curve fork near the lateral line, with the upper striae is flatter (Figure 1c).

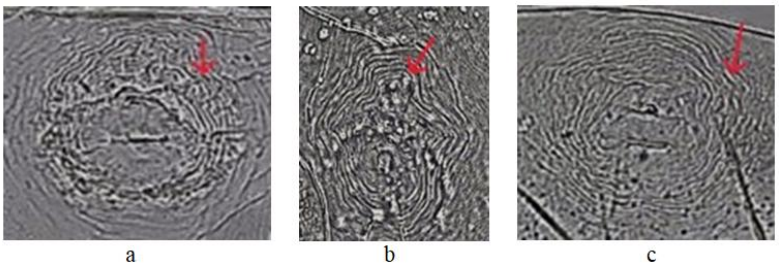

Figure 1 – The perineal pattern of root-knot nematodes infecting celery plants in Mahang Baru Village District, Labuan Amas Selatan, Hulu Sungai Tengah. (a) *M. javanica*; (b) *M. incognita*; (c) *M. arenaria* (Eisenback., 1981)

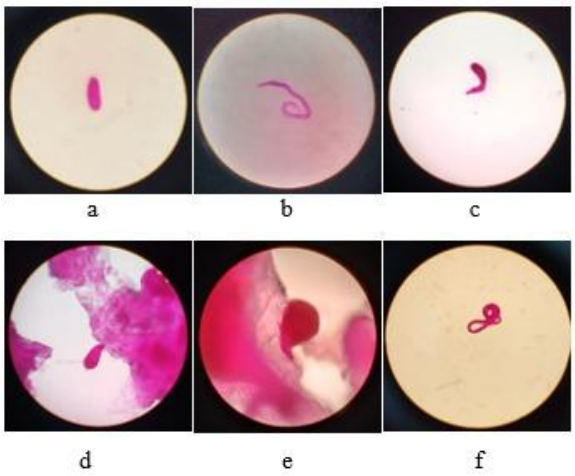

Figure 2 – *Meloidogyne* spp. stages in celery root tissue. (a)Eggs; (b) L2; (c) L3; (d) L4; (e) Female, and (f) Male

The nematode stages that can be observed in root tissue are eggs, larvae 1, 2, 3, and 4, and adults. *Meloidogyne* eggs are elongated oval (Figure 2a). Larva 2 is infective in the form of a worm in plant tissue (Figure 2b). Juvenile 2 will enlarge to become juvenile 3 (Figure 2c), body size increase to become juvenile 4 (Figure 2d), and develop and undergo a change in shape. The female nematode is shaped like a pear with a short neck and a rounded posterior part and resides in plant tissue (Figure 2e), while the male nematode is elongated and cylindrical (Figure 2f). *Meloidogyne* is a persistent endoparasitic nematode that causes root swelling.

DISCUSSION OF RESULTS

The development of RKN is believed to be influenced by variations in agricultural methods. Sukamaju Ujung practiced direct agriculture on land or soil. In West Mandiangin, specifically in Hamak Village, Jamil Village, Banyu Jaranih, and Mahang Baru, celery was cultivated using para-para or bamboo poles filled with soil and compost. This method allows for efficient weed control and easy monitoring of plant growth. Despite the need for continuous soil replacement and the shorter productive period of celery grown in containers compared to celery planted in the ground, research has shown distinct differences in the development of RKN between these two cultivation methods. Although some instances of RKN infection were found, the overall percentage was relatively low.

Fitriyanti and N. Aidawati (2022) have found three species of *Meloidogyne* on Sukamaju Ujung village, Sukamara village, and Kurnia village. In the current research, the same three

species were also discovered in an RKN-infected celery planting areas at the sample location in Mahang Baru Village, Labuan Amas Selatan District, Hulu Sungai Tengah. Kurniawati *et al*. (2017) found three *Meloidogyne* species, *M. incognita*, *M. arenaria*, and *M. javanica*, in Pacet Village, where the temperature was around 18-20°C during the day and 12-18°C at night. They also found the same three species plus one other species, *M. hapla*, in Cikole Village, Cihideung Village, and Ciputri Village, Bandung, West Java (Kurniawati *et al*., 2020). Balkan *et al*. (2019) found two species, *M. incognita*, and *M. javanica*, in the research area with temperatures of 29 - 31℃. The temperature during the research period fluctuated between 24 and 31℃. The climate in a location greatly influences the presence of microorganisms, including RKN. The optimum temperature for the growth of *M. arenaria* and *M. incognita* is 15-25℃ and 20-30℃ for *M. javanica* (Taylor, 1982).

The presence of more than one *Meloidogyne* species at a location indicates that the incidence of root knot disease is more severe than that caused by one species alone. More than two *Meloidogyne* species are sometimes found in the same habitat (Shurtleff & Averre, 2000). Sandy loam soil texture allows nematodes to move more easily between soil pores. Celery plants have a productive period of about one and a half years before being replaced with new celery plants. The consistent presence of hosts that are not rotated with other cultivated plants each year is also a contributing factor to the persistent presence and subsequent difficulty caused by these nematodes.

Based on data provided by local growers, root nodules have been a longstanding problem. Celery is widely cultivated in the Landasan Ulin Utara area because this area is the main supplier of vegetables. The growth of RKN is believed to originate from seeds that were previously sourced from RKN-infested regions. Consequently, by consistently cultivating this celery, the population of RKN continues to grow, ensuring its persistent existence.

The discovery of these three species in Mahang Baru is new information. Prior to conducting sampling in Hulu Sungai, specifically in Hulu Sungai Selatan and Hulu Sungai Tengah, the issue with celery was primarily stem rot caused by bacterial infection. The existence of RKN with a low level of attack may occur due to the use of infected seeds. These findings indicate that the three species found can negatively impact the growth of celery crops in the future and can also contribute to the spread of the pests to other plants, given that *Meloidogyne* has a very wide host range. It is necessary to implement concrete strategies and plans to effectively control RKN activities in the Landasan Ulin Utara area, Banjarbaru City. This area serves as a key hub for vegetable production in South Kalimantan. Similarly, efforts should be made to ensure that Mahang Baru village and other districts remain free from RKN attacks.

The frequency of pesticide application in celery production in Hulu Sungai was higher than that in Landasan Ulin Utara. Growers in Hulu Sungai increased the dose two to three times higher than recommended, which leads to better celery plant growth. This was different from the celery plants in Mahang Baru Village; the celery growth was less well maintained, and there were still weeds among the plants.

CONCLUSION

Apart from Sukamaju Ujung, RKN attacks were also found in Mahang Baru village, Labuan Amas Selatan District (Hulu Sungai Tengah). The attack intensity in Sukamaju Ujung was 85–90% with a galling index of 8–9 and a total population of 1049 nematodes/5 g roots, while in Mahang Baru village, the attack intensity was 15% with a galling index of 8 and the highest population number was 1282 nematodes/ 5 grams of root. This suggests the possibility of a more extensive spreading if preventive measures are not implemented promptly. Based on perineal pattern analysis, three *Meloidogyne* species, *M. incognita*, *M. arenaria*, and *M. javanica*, were found in Mahang Baru village.

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