Soil Types and their Physio – Chemical Properties for Population Development of Root Knot Nematode (Meloidogyne spp.) in Tomato (Solanum lycopersicum)

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Abstract — Root Knot Nematodes (RKN) (Meloidogyne spp.) is the major soil borne microorganisms causing severe losses in vegetable production in Sri Lanka. This experiment was conducted to determine the effect of the fourteen different soil types and their physio-chemical properties for population development of Meloidogyne spp on tomato crop. The population of RKN showed significant differences among different soil types. The maximum nematode population (Root Galling Index of 7.25, Number of knots of 165.25) were recorded in Red Yellow Podzolic – Imperfectly Drained soil with higher organic carbon (11.54%), phosphorus (3.30 ppm), potassium (369 ppm), sand (37.96%), moisture content (16.22%) and it was not significantly difference between Red Yellow Podzolic – Imperfectly Drained soil and Regosol. The minimum nematode population (Root Galling Index of 2.75, Number of knots of 51.75) was recorded in Reddish Brown Latosol – Imperfectly Drained soil with organic carbon (4.1% w/w), phosphorus (0.58 ppm), sand (64.66%), and moisture content (6.19%). Analysis of correlation coefficient showed that population of Meloidogyne spp. significantly positive correlated with phosphorus, potassium, nitrogen, EC, soil moisture and sand percentage while significantly negative correlated with the silt + clay percentage, soil temperature and soil pH. There was no significant correlation recorded with soil organic carbon content as it was clearly indicated that all the samples had very low percentage of organic carbon in compared to suppressive soils. Therefore, the study concludes all soil physic-chemical properties except organic carbon have direct effect on the development of population of Meloidogyne spp. and it is varied with the different soil types, hence it is vital to contemplate soil type and its physio-chemical properties when executing Integrated Nematode management programs for Meloidogyne spp. However, further investigations are required to study the direct effect of soil organic carbon on development of population of Meloidogyne spp.

Index Terms — Correlation coefficient, Meloidogyne spp., Physico-chemical properties, Soil types.

I. INTRODUCTION

The crop losses caused by the plant-parasitic nematodes are estimated around 100 billion dollars per year [1], [24], [30], and Meloidogyne spp. are the most important pathogens of a wide variety of host plants, causing serious economic losses, especially vegetable and other food crops [17], [21]. It is reported that intensity of crop losses of rice, many vegetables and fruits is very high due to RKN in Sri Lanka.

The management of nematodes is difficult than that of other pests because nematodes are mostly inhabited in the soil and usually attack the underground parts of the plants [32]. Stirling and Graham emphasis on importance of sustainable Integrated Nematode Management programme for nematode control [31]. Continuous application of adequate amounts of organic amendments improves soil fertility and help controlling nematodes in soil but it is not a usual practice in worldwide. Use of synthetic nematicide is a common practice for controlling the nematodes around the world but owing to environmental hazards their application has been restricted. Application of biological agents is another important way to manage plant parasitic nematode [16], but a few have been mass produced commercially, formulated and marketed for bio-control purpose and high level of control is rarely achieved.

However, soil type is a primary edaphic factor that may influence the damage potential of M. incognita on plant. The important of soil and its governing factors have been neglected many years. The lands currently available for agriculture have been exploited many years for crop production by addition of excessive fertilizer and pesticides and hence it is physically, chemically, and biologically degraded. The regulatory mechanisms that normally suppress nematode population have no longer functioning successfully and plants are unable to tolerate damage caused to the root system by nematodes [31]. Plants are unable to tolerate RKN damage in degraded soils because natural nematode suppressing mechanisms are not maintained in crop production. There are reports on carbon levels in agricultural soils are almost always more than 50% lower than their natural states. There are several studies to reveal the relationship between populations of Meloidogyne spp. in

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different soil types [37]. *Meloidogyne* spp. occurs more frequently and more abundantly in sandy soils than in clay soils [27], [11]. Hence, soil type or texture in a particular agricultural land has tremendously affects crop production with several factors [31]. The plant parasitic nematodes with prevailing favourable conditions in the soils have increase their movements, penetration of roots, reproduction, population densities in fields and relationship between pre plant population densities and crop productivity [27], [11].

The nematode movement and plant damage are determined greatly by soil physical and morphological properties [22]. Combination of an adequate porous space, particles size and inter-particle space and water content are key factors enhance proliferation of nematodes, since water films would allow their movement and therefore the access to find the food source [13]. It is well documented that well drained soils and macro porosity have an influence on the higher population of plant parasitic nematodes [7], [5], [1] and also soils with more than 50% of sand [3].

Soil texture is determined by a higher macro porosity which produces more air circulation and a consequent acceleration of the biological processes. The inter-aggregate space offers a better environment than the intra-aggregate space for development of nematodes populations and consequently, a correct morphological description of the soil texture becomes essential for nematode studies [22].

Therefore, it is important to assess the effects of soil properties on multiplication of plant parasitic nematode populations. Although there are some attempts have been taken to measure the effect of soil texture on nematodes population and infectivity [22], [9], [5] no studies have been carried out under tropical conditions until Amarasena [2], reported that the population of *Pratilenchus loosi* on tea varied with different soil types in different agro climatic zones in Sri Lanka.

Thus, the study was begun to investigate the survival of *Meloidogyne* spp. in different soil types and effect of soil physical and chemical properties on development of nematode population under Sri Lankan conditions.

### II. MATERIALS AND METHODS

The experiments were conducted in the screen house of the Division of Entomology and Nematology, Horticultural Crops Research and Development Institute, Gannoruwa, Sri Lanka during March, 2019 to March 2020. Thirteen soil types were collected from different Agriculture Instructor’s regions (AI regions) of Central Province of the country and Regosol soil type was collected from northern coastal area (*Kalpitiya*) where *Meloidogyne* infestation is high on vegetables and fruits (see Table 1). Collection of different soil types were done based on drainage classes which was identify according to landscape of the area.

The different soil types were sterilized separately with steam using special sterilizer for the period of six hours. This was done to keep the soil free from any organism. Especially from the *Meloidogyne* spp. Then soils were allowed to dry under normal air for one day and 21 cm diameter clay pots were filled with 3 kg of steam sterilized soil. A single seedling from nursery of Root Knot Nematode susceptible tomato variety, Katugastota Wilt Resistant (KWR) maintained in screen house was transplanted in each pot with different soil types. Second stage juveniles of *Meloidogyne* spp. collected from the cultures maintained at screen house on tomato variety KWR. Egg masses were separated and incubated in micro sieves (75-µm aperture, 20 mm diameter) for 24 hours to collect the second stage juveniles.

Inoculation was done a week after transplanting at the rate of 1,000 juveniles per plant, suspension of juveniles was drained into four holes made at the base of the plant by using a pipette.

Each soil type was replicated four times with Complete Randomized Design (CRD).

#### TABLE 1: DIFFERENT SOIL TYPES COLLECTED FOR THE STUDY FROM DIFFERENT PARTS OF SRI LANKA WITH GPS POINTS DURING 2019

| Soil types             | GPS points          | Location        |
|------------------------|---------------------|-----------------|
| Alluvial clay          | N 07.228537 E 80.603554 | Doluwa          |
| Alluvial sand          | N 07.269645 E 80.579155 | Gannoruwa      |
| Immature Brown Loamy soil | N 07.286324 E 80.608368 | Kandasale       |
| Low Humic Gley (LHG)   | N 07.242200 E 80.599288 | Kiribathkumbura |
| Reddish Brown Earth - Well drained (RBE-WD) | N 07.7342584 E 80.6814503 | Naula           |
| Reddish Brown Earth - Imperfectly drained (RBE-ID) | N 07.7328249 E 80.6814503 | Naula           |
| Reddish Brown Earth - Poorly drained (RBE-PD) | N 07.7277896 E 80.6807918 | Naula           |
| Reddish Brown Latosol - Well drained (RBL-WD) | N 07.458671 E 80.647390 | Bandarapola     |
| Reddish Brown Latosol - Imperfectly drained (RBL-ID) | N 07.458456 E 80.647189 | Bandarapola     |
| Reddish Brown Latosol - Poorly drained (RBL-PD) | N 07.458331 E 80.646801 | Bandarapola     |
| Red Yellow Podzolic - Well drained (RYP-WD) | N 06.9712111 E 80.797114 | Nuwara Eliya   |
| Red Yellow Podzolic - Imperfectly Drained (RYP-ID) | N 06.971764 E 80.766082 | Nuwara Eliya   |
| Red Yellow Podzolic - Poorly Drained (RYP-PD) | N 06.971765 E 80.796422 | Nuwara Eliya   |
| Regosol                | N 08.210532 E 79.730722 | Kalpitiya       |

Sixty days after inoculation, tomato plants were uprooted. Population development of *Meloidogyne* spp. was measured by calculating the number of egg masses per root system, number of root knots per one gram of root. The severity of root damage was estimated using a diagrammatic Root Galling Index chart [8]. Soil pH was measured with a pH meter. Soil temperature and soil moisture was measured with TDR – 150 soil moisture meters. Soil EC with EC meter. Organic matter content was measured by using loss ignition method. Soil total Nitrogen (N) was measured with Kjeldahl method, Soil available Phosphorus (P) was measured with Olsen method and soil available Potassium (K) using flame photo meter method [18]. Soil Particle size was calculated with simplified hydrometer method [12] to study the
relationship between nematode parameters with soil physio-chemical properties.

Duncan’s Multiple Range Test and Proc Catmod were used to determine the significance of the treatment effects at p<0.05 level. Regression analysis was done, and correlation coefficient was calculated to find out the relationship among different nematode parameters with soil physio-chemical properties at p<0.05. Data was statistically analyzed using Statistical Analysis Software (SAS) packages and Minitab. The Microsoft Excel (2016) computer software package was used to prepare all the graphs.

III. RESULTS

A. Population Development of Meloidogyne spp. in Different Soil Types

The population of the Meloidogyne spp. varied with soil types and it was significant at chi-square < 0.05 probability level with number of root knots, Root Galling Index, and number of egg masses per one gram of roots. The maximum number of root knots, 165.25 per gram of roots, highest mean number of Root Galling Index of 7.25 was recorded from Red Yellow Podzolic (RYP-ID) and maximum number of egg masses, 77.00 per root system was recorded from Reddish brown Earth (RBE-PD) soil (see Table 2).

The minimum number of Root Galling Index, 51.75 root knots per one gram of roots, Root Galling Index of 2.75 was recorded from Reddish Brown Latosol (RBL - ID) and it was significantly lower than other soil types except with RBE-PD (53.25 root knots per one gram of roots, Root Galling Index of 3.00) and RBL-PD (53.25 root knots per one gram of roots, Root Galling Index of 3.00) soil types (see Table 2).

| Treatments         | Mean value of Root Galling Index* ± SE | Number of Knot counts per g of root* ± SE | Egg masses counts per g of root* ± SE |
|--------------------|--------------------------------------|------------------------------------------|---------------------------------------|
| Alluvial clay      | 4.25 ± 0.25 de                       | 71.75 ± 5.40 cdef                       | 35.00 ± 5.40 bdc                      |
| Alluvial sand      | 5.00 ± 0.00 cd                       | 80.00 ± 3.80 cde                       | 61.00 ± 2.40 ab                      |
| IBL                | 4.50 ± 0.28 de                       | 77.75 ± 6.40 def                       | 52.00 ± 1.58 abc                     |
| LGH                | 5.50 ± 0.28 c                         | 88.75 ± 4.70 bcd                       | 35.75 ± 6.25 bcd                     |
| RBE-WD             | 5.75 ± 0.25 bc                        | 98.00 ± 1.70 bcd                       | 35.75 ± 6.00 bcd                     |
| RBE-ID             | 5.00 ± 0.40 cd                        | 81.25 ± 4.20 cde                       | 42.25 ± 6.00 bde                     |
| RBE-PD             | 3.00 ± 0.40 f                         | 53.25 ± 5.90 ef                        | 77.00 ± 5.00 a                       |
| RBL-WD             | 4.00 ± 0.00 e                         | 68.25 ± 4.25 def                       | 63.00 ± 7.20 ab                      |
| RBL-ID             | 2.75 ± 0.25 f                         | 51.75 ± 4.00 f                         | 61.75 ± 7.20 ab                      |
| RBL-PD             | 3.00 ± 0.00 f                         | 53.25 ± 5.57 ef                        | 51.00 ± 6.70 abc                     |
| RYP-WD             | 6.50 ± 0.28 ab                        | 100.50 ± 6.14 bcd                      | 55.00 ± 6.20 ab                      |
| RYP-ID             | 7.25 ± 0.25 a                         | 165.25 ± 7.14 a                        | 20.75 ± 3.70 d                      |
| RYP-PD             | 7.00 ± 0.00 a                         | 116.25 ± 7.30 b                        | 24.75 ± 6.40 cd                     |
| REGOSOL            | 6.75 ± 0.25 a                         | 102.25 ± 4.97 bc                       | 24.50 ± 1.60 dc                     |
| NORMAL             | 4.25 ± 0.25 de                        | 74.50 ± 6.18 cde                       | 39.00 ± 2.10 bdc                    |

* Different simple letters represent values within columns that are significantly different at p ≤ 0.05 based on the Duncan’s multiple range test according to soil types.

The population density of Meloidogyne spp. can be varied with soil types and it may be due to changes in soil parameters in different soils types [4]. Studies on the effects of soil type on the reproduction of Meloidogyne incognita and potential of damage to soybean has shown that higher nematode damage in sandy soil types and less nematode damage in clay soil types, highest reproduction potential in coarse sandy loam soils by M. incognita and M. javanica species [28] and also the rate of nematode reproduction also varied greatly with soil types [37].

B. Soil Physio-chemical Properties on Nematode Parameters

Positive correlation was observed with population of Meloidogyne spp. with soil moisture (g), soil EC (b), organic carbon (f), nitrogen (e), phosphorous (d), potassium (c), sand percentage (i) while negatively correlate with the soil pH (a), soil temperature (h) and clay + silt percentage (j) at P ≥ 0.01 level of significance (Fig. 1 and 2).

pH vs Meloidogyne population: Soil pH varied from 4.50 to 7.10 and most of the soil samples (54.23%) had pH less than 6.00. The highest pH of 7.10 was recorded from PBE-PD soil and had low Meloidogyne population (Root Galling Index of 3.00 and the number of root knots per g of roots 53.25) and the lowest pH 4.50 was recorded with RYP-ID with the highest Meloidogyne population (Root Galling Index of 7.25 and number of root knots per g of root 165.25) (see Table 2 and 3). Scatter diagram given in Fig. 1a and Fig. 2a showed that Meloidogyne population has increased when the pH was in the range of 4.5 to 6.5 and pH above 7.0, the nematode population decreased, and it was negatively correlated with R²= 0.7095.

Present study, revealed that the Meloidogyne population changed with soil pH and EC as reported by other authors where the nematode population negatively related to soil pH while positively related to EC. Asif reported population density of Meloidogyne spp. had significantly negative correlation with soil pH at (p<0.05) and population increased when the pH was in the range of 5.0 - 7.0 and pH above 7.0, the nematode population decreased. Also, high Population densities of Meloidogyne spp. reported when the soil pH ranges between 4.5 and 6.0 in different sampling sites in Kenya [36]. It is also reported that soil pH had strong negative correlation with population density of Meloidogyne spp. [25].

Sarah explained the negative relationship between nematode population and soil pH on Pratilenchus brachyurus in pineapple and found that relationship between soil pH and the nematode population disappeared during the nematode development and multiplication inside the root system but influenced at early stage of plant growth before or during the nematode penetration into roots [29].

The nematodes at the root-soil interface could be influenced by gradients formed along the root axis and in the rhizosphere due to chemical strategies for nutrient mobilization which induce modification of pH and redox potential [23] and Meloidogyne spp. is attracted to roots and contact is maintained by the low pH and the lower redox potentials of the root surface [6], [26]. Therefore, soil pH has to be corrected to support the plant growth and to suppress the nematode population in management of the nematodes.

EC vs Meloidogyne population: The highest EC value 0.1450 ds was recorded from LHG soil with higher
Meloidogyne population (Root Galling Index of 5.50 and number root knots per g of roots of 88.75) and the lowest EC (0.0170 ds) was recorded from RBE-ID with higher Meloidogyne population (Root Galling Index of 5.00 and number of root knots per g of roots of 81.25) (see Table 3 and 4). Whereas Root Galling Index is positively correlated with EC with R² of 0.7827 (Fig 1b) and with number of root knots per g of roots was significant with R² of 0.3357(Fig 2b). Yavuzaslanoglu also reported Similar correlations between soil EC and Meloidogyne spp [38]. The study proved that an inverse relationship between soil EC and pH, consequently, increased soil EC had result decreased soil pH and increased densities of Meloidogyne spp. [38]. Negative correlation between soil pH and soil EC was also reported by previous studies [14]. Study further reported that soil EC was inversely related to the soil texture.

**TABLE 3: DIFFERENT SOIL PHYSICAL AND CHEMICAL PARAMETERS MEASURED DURING THE STUDY IN DIFFERENT SOIL TYPES**

| Treatments     | pH   | EC (ds) | Potassium (ppm) | Phosphorus (ppm) | Percentage Nitrogen (w/w) | Percentage Organic C (w/w) | Sand % | Clay + silt % | Temperature, °C | Soil Moisture % |
|----------------|------|---------|-----------------|-----------------|---------------------------|---------------------------|--------|---------------|-----------------|-----------------|
| Alluvial clay   | 5.10 | 0.0416  | 130             | 2.19            | 3.00                      | 4.1                       | 61.79  | 38.02         | 29.50           | 32.72           |
| Alluvial sand   | 5.41 | 0.0354  | 219             | 1.47            | 0.20                      | 3.2                       | 74.73  | 25.27         | 28.60           | 15.57           |
| IBL            | 5.90 | 0.0290  | 237             | 1.69            | 0.21                      | 1.6                       | 75.16  | 24.83         | 28.26           | 32.31           |
| LHG            | 5.64 | 0.1450  | 152             | 0.60            | 0.60                      | 7.0                       | 64.98  | 35.01         | 28.20           | 15.87           |
| RBE-WD         | 5.60 | 0.0270  | 291             | 0.70            | 0.25                      | 3.0                       | 70.66  | 29.33         | 28.90           | 17.27           |
| RBE-ID         | 4.71 | 0.0170  | 189             | 0.60            | 0.10                      | 1.7                       | 74.60  | 25.39         | 28.60           | 32.99           |
| RBE-PD         | 7.10 | 0.1330  | 113             | 0.50            | 0.21                      | 4.5                       | 67.10  | 32.80         | 30.70           | 5.66            |
| RBL-WD         | 5.90 | 0.0340  | 163             | 0.70            | 0.30                      | 6.0                       | 64.87  | 35.12         | 28.60           | 6.94            |
| RBL-ID         | 6.00 | 0.0440  | 174             | 0.58            | 0.20                      | 4.1                       | 64.66  | 35.33         | 29.60           | 6.19            |
| RBL-PD         | 5.30 | 0.0340  | 105             | 0.60            | 0.30                      | 3.1                       | 71.93  | 28.07         | 29.60           | 10.56           |
| RYP-WD         | 5.30 | 0.0940  | 217             | 1.20            | 0.30                      | 5.0                       | 71.13  | 28.86         | 28.75           | 19.11           |
| RYP-ID         | 4.50 | 0.0930  | 369             | 3.30            | 0.50                      | 11.5                      | 77.06  | 22.93         | 28.00           | 16.22           |
| RYP-PD         | 5.10 | 0.0720  | 422             | 4.14            | 0.40                      | 12.1                      | 74.67  | 25.30         | 28.65           | 14.57           |
| REGOSOL        | 6.70 | 0.0560  | 170             | 2.55            | 0.51                      | 0.7                       | 84.72  | 15.20         | 28.75           | 3.56            |
| NORMAL         | 6.80 | 0.1930  | 250             | 2.34            | 0.30                      | 6.2                       | 71.90  | 28.10         | 29.75           | 4.15            |

_NPK vs Meloidogyne population:_ Correlation studies with Nitrogen (N), phosphorous (P) and potassium (K) have shown positive correlation with the Root Galling Index (R² of N = 0.5265, P = 0.6021 and K = 0.2616) (Fig 1c, Fig 1d, Fig 1e) and number of root knots (R² of N = 0.4304, P = 0.3673 and K = 0.6487) (Fig 2c, Fig 2d, Fig 2e). The highest soil potassium content of 422 ppm and phosphorus content of 4.14 ppm recorded from RYP-PD with highest Meloidogyne population (Root Galling Index of 7.00 and number of root knots of 116.25). The highest soil nitrogen content of 3.00 % was recorded from alluvial clay soil. The lowest soil potassium content of 105 ppm was recorded from RBL-PD, soil phosphorus content of 0.50 ppm from RBE-PD and lowest soil nitrogen content of 0.10 % was from RBE-ID soil type.

The findings of previous studies confirmed population density of Meloidogyne spp. had significantly positive correlation with potassium and phosphorus content in the soil [4]. Highest nematode population recorded in sandy soil having greater potassium and least nematode population reported in sandy loamy soil with least phosphorous. The study further reported population density of Meloidogyne spp. had significantly positive correlation with nitrogen content of soil. The highest nematode population had recorded from sandy loamy soil type having greater nitrogen (165kg ha⁻¹) and least nematode population in sandy loamy type of soil with least nitrogen.116 kg ha⁻¹. Higher level of nitrogen present in the soil commonly reduces soil pH and causes ammonium and aluminium toxicity or introduces sufficient salt to harm soil biota [34].

_Organic Carbon, sand, and Clay + silt vs Meloidogyne population:_ Highest organic carbon content (12.1 % w/w) recorded from RYP-PD where sand content was 74.67% and Clay + silt content was 25.30%. But highest sand content of 84.72% and lowest organic carbon percentage content of 0.7 w/w and Clay + silt content of 15.20% recorded from Regosol with higher Meloidogyne population because of higher sand percentage of the soil. Highest Clay + silt content of 38.02% recorded from Alluvial clay. Correlation studies on organic carbon content showed no strong relationship with Meloidogyne population (R² for Root Galling Index of 0.0028 and number of knots of 0.0836) Fig.1f, Fig. 2f). Percentage sand and clay + silt showed opposite relationships with population, where positive relationship with sand (R² of Root Galling Index of 0.5335 and number of knots of 0.1694) (Fig. 1i, Fig.2i) and negative relationship with Clay + silt percentage (R² of Root Galling Index of 0.5470 and number of knots of 0.1136) (Fig.1j, Fig. 2j).

Organic carbon content of a soil represents the availability of organic matter. Soil organic matter nearly contents all the nitrogen, majority of phosphorous and sulfur and it is the principal long-term storage medium and short term source of these nutrients [35], [31]. A typical soil aggregates bound with organic matter give niche habitat to the microorganisms. Therefore, content of organic matter in the soil play main role in management of Nematodes [31]. However, in this study, the population density of Meloidogyne spp. had not shown significant correlation with organic carbon of soil. It may be due to low content of the soil organic matter in the tested soils. It has reported significant positive correlation nematode...
population when soil content greater organic carbon (0.36%) and least nematode population with least organic carbon (0.24%) [4]. Marshela reported that organic matter is associated with the highest densities of *Tylenchulus semipenetrans* [20]. Higher sand textured soils restrict the sting nematode reproduction on strawberry and soya bean in the different soil [28]. Also, nematode movements directly related, and movement of sting nematode is strictly restricted in clay soils [14]. This was further clarified by Stirling and Wallace that soil nematode population is mostly depending on the soil particle and pore size and they will move when the pores are in optimal size and full of water. When the pores are full of water but not in optimal size to move, movement inhibit and egg hatch will be occurred and population decrease when the soil moisture decreases [31], [33].
Fig. 1. Relationship between different physio-chemical parameters and Root Galling Index of *Meloidogyne spp.* (a) Soil pH (b) Soil EC (c) Potassium (d) Phosphorous (e) Nitrogen (f) Organic carbon (g) Soil moisture (h) Soil temperature (i) Sand percentage (j) Percentage of clay+silt.
Soil moisture and soil temperature vs Meloidogyne population: Soil moisture and soil temperature has showed two opposite direction of relationship with *Meloidogyne* population. Soil temperature and *Meloidogyne* population showed negative correlation \( R^2 \) of Root Galling Index of 0.3686 and number of knots of 0.1441 (Fig. 1h and Fig. 2h). The temperature was ranged from average of 28.2 °C to 30.7 °C in all the soils while *Meloidogyne* population varied significantly among all the soils (see Table 2 and 3). The highest nematode population was reported in RYP-ID with lower temperature (28.0 °C) and lowest nematode population was reported in RBL-ID with the higher temperature (29.6 °C). Soil moisture and *Meloidogyne* population showed positive correlation of \( R^2 = 0.4803 \) for Root Galling Index and \( R^2 = 0.4860 \) for number of root knots (Fig. 1g and Fig. 2g).

Highest moisture content was recorded from Alluvial clay and RBE-ID soils, while lowest moisture content was recorded from Regosol soil. The highest *Meloidogyne* population was found in RYP-ID with the higher moisture (16.22%). Lowest *Meloidogyne* population was found in RBL-ID with the lowest moisture (6.19 %).

Soil moisture is most important component of the soil environment because it carries and dissolves the nutrients, and also affects the survival and movement of soil microorganisms specially for nematodes. Movement of the nematodes are mainly depending on the availability of the water in soil pores. Further soil moisture content has important effect on the soil temperature and aeration [31]. Significant correlations recorded between nematode densities and soil bulk density and moisture at various times of the year.
whereas the reproduction of *Meloidogyne incognita* tended to be high in coarse textured soils [15]. Asif reported that population density of *Meloidogyne* spp. had showed significantly positive correlation with soil moisture [4]. Multiplication of root knot nematode was founded to be highest when soil moisture is more and multiplication of root knot nematode decrease as the moisture content decrease. Higher soil moisture is favorable for nematode multiplication [4].

Amarasena from Sri Lanka reported the differences of soil temperature on *Pratylenchus loosi* population were significant in different study locations with different tea lands [2]. A negative correlation between soil temperature and *P. loosi* population in majority of the tea lands were recorded [2]. It is reported population density of *Meloidogyne* spp. shown significantly negative correlation with soil temperature [4] and *B. longicaudatus* populations reproduced more on corn at 25 °C and 30 °C than at 20 °C or 35 °C [37].

### IV. CONCLUSION

The study concludes, soil type and their physio-chemical properties affect population development of *Meloidogyne* spp. in vegetable cultivation in Sri Lanka. The sand percentage, soil EC and soil temperature are one of the most determining factors for the development of *Meloidogyne* population. Effect of soil organic carbon was not evident due to poor organic matter contents in cultivated soils. It was elucidated that heavy use of inorganic fertilizer leads to increase in *Meloidogyne* incidences in vegetable lands.

Therefore, it will be vital to contemplate the effect of soil physio-chemical properties of different soil types on the development of *Meloidogyne* population in particular location, when developing of a sustainable programme for management of *Meloidogyne* spp.

However, further Investigations are required to study the direct effect of soil organic carbon on development of population of *Meloidogyne* spp.

According to the world literature, soil physical, biological and chemical properties have declined elsewhere in the world due to vigorous and continuous cultivation and further, heavy use of fertilizers and pesticides. However, the information available in Sri Lanka are scarce on change of soil pest populations with declining soil physical, chemical and biological properties. Therefore, the information generated from this study will open-up new research areas to investigate and help converting suppressive soils to conducive soils to increase productivity.

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