Root morphology of several potato varieties – infected Meloidogyne spp. and addition of organic matters

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Abstract. This research was aimed to determine root morphology of several potato varieties which were applied by organic materials into the planting medium inoculated nematodes. The research was conducted at Research Station of Horticulture in Berastagi, Sumatera Utara on May to November 2016. The randomized block design was used with two factors; the first factor was K1 = Positive control (no use compost / inoculation of nematodes) K2 = Negative control (no use compost / no inoculation of nematodes) K3 = Using compost mucuna and inoculation of nematode, K4 = Using compost peanuts and inoculation of nematodes and the second factor was potato varieties (Tenggo, Maglia, and Margahayu). The results showed that organic matters increased the shoot fresh weight, the root fresh weight, the tubers weight and the number of tubers, root diameter, root length. However, organic matters also increased the number of nematodes. Varieties of Tenggo and Maglia showed significant affect to all observed characters. The interaction of the two treatments had significant affect to the shoot fresh weight, the number of root-knot, and the number of tubers, root length. However, no significant affect was observed in root wet weight, and tuber weight.

1. Introduction
Potato (Solanum tuberosum L.) is an important crop in Indonesia. In terms of the value of its nutrition value, is one type of potato tubers that can serve as a potential source of nutrition. The nutritional substances contained in Potato tubers, among others, carbohydrates, minerals, iron, magnesium, phosphorus, sodium, calcium and potassium, protein and vitamins especially vitamin C and vitamin B1. In addition, the potatoes also contain fat in relatively small amounts, i.e., of 1.0-1.5 percent [1].

Based on the data of the Central Bureau Of Statistics in district of Berastagi in 2015. Potato production in 2014 of 2,333 tons with an area 147 Ha harvest, while in 2013 with a vast harvest 104 Ha was able to produce production 2,754 tons. Based on the above it can be concluded that there has been a significant decline in spite of the addition of a vast harvest [2].

One of the causes of the decline in crop production is the presence of plant pest organism, one of which is root-knot nematodes (Meloidogyne spp.). In addition to attacking the potato nematodes also attacked crops of tomatoes, cucumbers, carrots and others [3].
Control efforts have been done in an attempt to suppress the nematode population density in the field. One of these by using nematicide. Different types of nematicide that can be used to take control of *Meloidogyne spp.* such as Furadan, Carbofuran, Fenamilos and others. The effectiveness of nematicide depends on the dose and mode of application [4].

Nematode control with use of chemical nematicide still play an important role. This occurs because other means of control have not been able to provide satisfactory results. But controlling nematodes with nematisidea may cause negative effects for the environment and the organism was not target. This is because the nematicidecan be toxic to humans and pets. Additionally nematicide can be persistent in the soil, causing soil to water pollution, as well as a slew of other organism they are not natural enemies include target nematodes such as fungi, bacteria and other microorganisms. In an attempt to maintain environmental sustainability, control of nematodes is directed at controlling biological basis like using antagonistic microorganisms (natural enemies),organic materials, crop plants, and plants that are nutritious as pesticides [5]. Legumes can serve as an amendement to the soil and plants cover the soil to reduce the population of nematodes. Plant legumes can produce organic material such as a Lectin, Rotenone Deguelin, and Tephrosin are used as pesticides. The use of nuts as organic amendment to pest control may not yet be widely practice except in the developing countries, but the practice is likely to be one of the alternatives in the future. Most species examined to start constituent legumes nematicial [6].

One of the techniques of breeding resistance disease that using varieties resistant. Resistant varieties are varieties of plant that have the ability to reject or avoid, recover back from the attack of pests or disease. Resistant varieties are varieties that are able to produce more and better compared to other varieties of pest populations at the level of the same [7].

2. Material and methods
The research was conducted at Research Station of Horticulture in Berastagi, Sumatera Utara on May to November 2016. The randomized block design was used with two factors ; the first factor was organic materials (mucuna and peanut compost) and the second factor was potato varieties (Tenggo, Maglia, and Margahayu). Against a significant variety of prints, continued follow-up analysis by using Duncan Multiple Range Test at a 5% level [8]. The materials used were plant seed potato varieties (Tenggo, Margahyu, Maglia), waste plant, Leguminoceae (peanuts, mucuna), top soil, the roots-knot of tomato plants.

2.1. Estimation of genetic parameter
Prediction component of genetic diversity, variance of interaction genotype and environment , environmental diversity and variance of phenotypes. Performed in the following way :

\[\sigma^2_e = \text{M1} \]
\[\sigma^2_g = \frac{\text{M3-M2}}{\text{rl}} \]
\[\sigma^2_p = \sigma^2_g + \sigma^2_{AB} \]

Description : \(\sigma^2_e\) error variance ; \(\sigma^2_g\) genetic variance ; \(\sigma^2_p\) phenotype variance\(\sigma^2_{AB}\) interaction genetic and environment variance

The value of heritability \(h^2\) in the broad sense is :

Heritability \(h^2\) mean base = \(\frac{\sigma^2_g}{\sigma^2_p}\) x 100% \(\quad \text{(4)}\)

Broad or narrow of genetic diversity value of a character depends on genetic variance. Coefficient of genetic variance predictable by knight equation

Coefficient genetic variance = CGV = (\(\sqrt{\sigma^2_g / x}\) X 100% \(\quad \text{(5)}\))
Description : $\sigma^2_g$ genetic variance

Criteria: narrow coef genetic diversity (0-10%) moderate (10-20%) and wide (>20%).

2.2. Correlation

Analysis correlation was used to determine character related to main characters, to improve the follow response in the implementation of indirect selection. Analysis of correlation calculated by Gaspersz

$$r_{xy} = \frac{n \Sigma xiyi - (\Sigma xi) (\Sigma yi)}{\sqrt{(n \Sigma xi^2 - (\Sigma xi)^2)(n \Sigma yi^2 - (\Sigma yi)^2)}}$$

Description : $r_{xy}$ = correlation of variable $x$ and $y$; $n$ = number of observations object; $x$ = value of variable $x$; and $y$ = value of variable $y$. This analysis can be used to find out which morphology characters correlated with outcomes, so it can be made into character selection.

3. Results and Discussions

The results (Table 1,2,4,5,6,7) in some varieties of potatoes with the applied of the organic material showed that the applied of the organic material in the form of compost peanut and mucuna would increased all parameters, because with the applied of the organic material will increase the availability of nutrient elements in soil, improve the structure of the soil and improve soil in water binding, so plants can grow and thrive [9].

| Table 1. The shoot fresh weight on each treatment organic materials and potato varieties |
|----------------------------------------|--------|--------|--------|
| Organic materials | Varieties | Mean |
|----------------|-------|-------|
| V1 | V2 | V3 |
| K1 | 8.93c | 5.2c |
| K2 | 0.92e | 4.15c |
| K3 | 7.39cd | 21.12a |
| K4 | 7.49cd | 14.97b |
| Mean | 17.58a | 4.2c |

Description : K1 = Positive control (no use compost / inoculation of nematodes) K2 = Negative control (no use compost / inoculation of nematodes) K3 = Using compost mucuna and inoculation of nematode. K4 = Using compost peanuts and inoculation of nematodes. V1 = Tenggo variety. V2 = Maglia variety. V3 = Margahayu variety. The figures followed a different letter notation is different based on the significant test of multiple distance duncan at a 5% level.

The results (Table 3) in some varieties of potatoes with the applied of the organic material showed that the applied of the organic material in the form of compost peanut and compost mucuna can not suppress the growth and development of nematodes.

However, the granting of organic compost and compost peanut mucuna shows the result of a higher number of root-knot than positive control (no use compost / inoculation of nematodes). This is due to the applied of the organic material in the form of composting and compost soil mucuna beans are able to improve the physical properties of the soil, keeping the water availability in the soil pore spaces of the soil as well as add that makes soil conditions supporting the growth and development of nematode[9]. Yet despite the number of root-knot administering more organic matter in the form of composting and compost soil mucuna beans is capable of supporting the growth and development of the plant so that plant potatoes stay afloat against attack nematodes.
Table 2. The root fresh weight on each treatment organic materials and potato varieties

| Organic Materials | Varieties | Mean |
|-------------------|-----------|------|
|                   | V1        | V2   | V3   |      |
| K1                | 2.04      | 2.76 | 0.22 | 1.68b|
| K2                | 0.66      | 3.08 | 0.47 | 1.40b|
| K3                | 5.93      | 8.52 | 2.3  | 5.58a|
| K4                | 3.07      | 8.56 | 1.59 | 4.41a|
| Mean              | 2.93b     | 5.73a| 1.15c|

Description: K1 = Positive control (no use compost / inoculation of nematodes) K2 = Negative control (no use compost / no inoculation of nematodes) K3 = Using compost mucuna and inoculation of nematodes. K4 = Using compost peanuts and inoculation of nematodes. V1 = Tenggo variety. V2 = Maglia variety. V3 = Margahayu variety. The figures followed a different letter notation is different based on the significant test of multiple distance duncan at a 5% level.

Table 3. Number of root-knot on each treatment organic materials and potato varieties

| Organic Materials | Varieties | Mean |
|-------------------|-----------|------|
|                   | V1        | V2   | V3   |      |
| K1                | 169.44cd  | 232.89c| 5.89e| 136.07c|
| K2                | 1.89e     | 2.22e | 1.22e| 1.78b |
| K3                | 384.22b   | 406.89b| 93.33d| 294.81a|
| K4                | 358b      | 501a | 154.78cd| 337.93a|
| Mean              | 228.39a   | 285.75a| 63.81b|

Description: K1 = Positive control (no use compost / inoculation of nematodes) K2 = Negative control (no use compost / no inoculation of nematodes) K3 = Using compost mucuna and inoculation of nematodes. K4 = Using compost peanuts and inoculation of nematodes. V1 = Tenggo variety. V2 = Maglia variety. V3 = Margahayu variety. The figures followed a different letter notation is different based on the significant test of multiple distance duncan at a 5% level.

Table 4. The root diameter on each treatment organic materials and potato varieties

| Organic Materials | Varieties | Mean |
|-------------------|-----------|------|
|                   | V1        | V2   | V3   |      |
| K1                | 5.26      | 6.12 | 3.19 | 4.86bc|
| K2                | 4.17      | 5.42 | 2.95 | 4.18c |
| K3                | 5.83      | 6.74 | 5.23 | 5.94ab|
| K4                | 4.93      | 8.78 | 5.37 | 6.36a |
| Mean              | 5.05b     | 6.77a| 4.18b|

Description: K1 = Positive control (no use compost / inoculation of nematodes) K2 = Negative control (no use compost / no inoculation of nematodes) K3 = Using compost mucuna and inoculation of nematodes. K4 = Using compost peanuts and inoculation of nematodes. V1 = Tenggo variety. V2 = Maglia variety. V3 = Margahayu variety.
variety. The figures followed a different letter notation is different based on the significant test of multiple distance duncan at a 5% level.

Based on the results of (Table 1-7) Tenggo varieties and maglia varieties showed better result on all parameters than margahayu varieties. It is alleged to be caused by the nature of the distinction or excelence of each variety complies with its own genotype.

**Table 5.** The root length on each treatment organic materials and potato varieties

| Organic Materials | Varieties | Mean |
|-------------------|-----------|------|
|                   | V1        | V2   | V3   |        |
| K1                | 25.78b    | 24.06bc | 8.72e | 19.52b |
| K2                | 22.44bc   | 35.28a | 22.94bc | 26.89a |
| K3                | 30.89a    | 34.22a | 20.00c | 28.37a |
| K4                | 33.06a    | 35.00a | 15.39d | 27.81a |

Mean 28.04b 32.14a 16.76c

Description : K1 = Positive control (no use compost / inoculation of nematodes) K2 = Negative control (no use compost / no inoculation of nematodes) K3 = Using compost mucuna and inoculation of nematode. K4 = Using compost peanuts and inoculation of nematodes. V1 = Tenggo variety. V2 = Maglia variety. V3 = Margahayu variety. The figures followed a different letter notation is different based on the significant test of multiple distance duncan at a 5% level.

**Table 6.** The tubers weight on each treatment organic materials and potato varieties

| Organic Materials | Varieties | Mean |
|-------------------|-----------|------|
|                   | V1        | V2   | V3   |        |
| K1                | 9.12      | 13.19 | 3.85  | 8.72b  |
| K2                | 15.11     | 12.40 | 5.33  | 10.94b |
| K3                | 48.97     | 51.88 | 23.25 | 41.37a |
| K4                | 42.10     | 44.35 | 21.70 | 36.05a |

Mean 28.82a 30.45a 13.53b

Description : K1 = Positive control (no use compost / inoculation of nematodes) K2 = Negative control (no use compost / no inoculation of nematodes) K3 = Using compost mucuna and inoculation of nematode. K4 = Using compost peanuts and inoculation of nematodes. V1 = Tenggo variety. V2 = Maglia variety. V3 = Margahayu variety. The figures followed a different letter notation is different based on the significant test of multiple distance duncan at a 5% level.

**Table 7.** The number of tubers on each treatment organic materials and potato varieties

| Organic Materials | Varieties | Mean |
|-------------------|-----------|------|
|                   | V1        | V2   | V3   |        |
| K1                | 3.78de    | 3.00ef | 1.67g | 2.81b  |
| K2                | 2.56fg    | 1.89g | 2.00g | 2.15b  |
| K3                | 10.56a    | 7.78b | 4.67cd | 7.67a  |
| K4                | 9.22a     | 7.11b | 5.11c | 7.15a  |

Mean 6.53a 4.94b 3.36c
Description: K1 = Positive control (no use compost / inoculation of nematodes) K2 = Negative control (no use compost / no inoculation of nematodes) K3 = Using compost mucuna and inoculation of nematode. K4 = Using compost peanuts and inoculation of nematodes. V1 = Tenggo variety. V2 = Maglia variety. V3 = Margahayu variety. The figures followed a different letter notation is different based on the significant test of multiple distance duncan at a 5% level.

The value of the heritability some of the varieties tested showed high criteria (Table 8). This show that some varieties are tested against genetic diversity contributes to phenotype in some organic material tested.

Table 8. The value of the expect variety genotype and heritability broad sense as well as coefficients of genetic diversity

| Characters          | σ²G  | h²bs | Criteria | CGD(%) | Criteria |
|---------------------|------|------|----------|--------|----------|
| Shoot fresh weight  | 5373 | 0.97 | High     | 2.50   | High     |
| Root fresh weight   | 700.08 | 0.99 | High     | 1.06   | High     |
| Root length         | 8414.76 | 0.99 | High     | 3.57   | High     |
| Root diameter       | 225.96 | 0.99 | High     | 2.82   | High     |
| Number of root-knot | 1653651 | 0.98 | High     | 146.96 | High     |
| Number of tubers    | 311.28 | 0.98 | High     | 0.08   | High     |
| Tubers weight       | 11317.56 | 0.99 | High     | 0.23   | High     |

Description: σ²G = Genotype variety. h²bs = heritability broad sense. CGD = Coefficient of genetic diversity

Based on the correlation of (Table 9) can be seen that all the parameters are correlated positively indicated by the value of the correlation that is very significant. This shows that every parameter is correlated with each other.

Table 9. Corelation between morphological Characters with the Character of production and the number of root-knot potatoes

|        | RL  | TW  | NT  | SFW | RFW | NRK |
|--------|-----|-----|-----|-----|-----|-----|
| TW     | 0.565** |     |     |     |     |     |
| NT     | 0.482** | 0.819** |     |     |     |     |
| SFW    | 0.615** | 0.792** | 0.749** |     |     |     |
| RFW    | 0.624** | 0.772** | 0.577** | 0.797** |     |     |
| NRK    | 0.554** | 0.745** | 0.787** | 0.777** | 0.790** |     |
| RD     | 0.557** | 0.486** | 0.437** | 0.557** | 0.722** | 0.661** |

Description: RL = root length. RD = root diameter. TW = tubers weight. RFW = root fresh weight. NRK = number of root-knot. SFW = shoot fresh weight. NT = number of tubers. * = corellate the significant on the extent 0.05; ** = corellate the significant on the extent 0.01.

4. Conclusions
1. Varieties Tenggo and Maglia shows growth and better production compared with margahayu varieties based on The shoot fresh weight. root fresh weight. tubers weight and number of tuber.
2. Applied organic materials compost peanut and compost mucuna can increase the growth and production of potato plants on medium inoculated nematodes

3. Highly heritability and correlation show on shoot fresh weight, root fresh weight, root length, root diameter, number of root-knot, number of tubers, and tubers weight. All parameters shown significant correlation. That means all parameters: shoot fresh weight, root fresh weight, root length, root diameter, number of root-knot, number of tubers, and tubers weight potentially used for character selection to early selected resistance varieties to nematode

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