Responses of four varieties of carrot plant (*Daucus carota* L.)
grown in medium latitude to different dosages of fertilization

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**Abstract.** A study was conducted to investigate the effect of different rates of NPK fertilization on growth and yield of carrot plants in medium latitude. The experiment was undertaken in Setiling Village, Central Lombok (at ca. 650 m amsl) and arranged according to a RCBD two factors: variety (v) and dosages of NPK fertilization (n). The first factor were four carrot varieties: Gundaling (v1), Kirana (v2), New Nantes (v3) and New Kuroda (v4), while the second factor were four dosages of NPK fertilization: 50 kg/ha (r1), 100 kg/ha (r2), 200 kg/ha (r3) and 400 kg/ha (r4). The results showed that there was no interaction between carrot varieties and rate of NPK fertilization on influencing growth and yield of carrot in medium latitude. However, growth and yield of carrot in medium latitude were significantly influenced by variety and rate of NPK fertilization, as shown by differences in the ratio of above and below ground biomass, tap-root weight, tap-root diameter and the ratio between cortex and stele. Accordingly the suitable variety for cultivation in the medium latitude was Gundaling variety (v1), with a higher growth and yield were obtained by NPK fertilization at rate of 200 kg/ha (n3).

1. **Introduction**

Carrot (*Daucus carota* L.) is an important root vegetable in Indonesia due to the demand and nutritional value. The carrot taproot contains carbohydrates, fiber, vegetable fat, protein, calcium, iron, magnesium, manganese, phosphorus, potassium, zinc, sodium, thiamine, riboflavin, niacin, pantothenic acid, vitamin B6, folic acid, vitamin A, vitamin C, vitamin E and vitamin K [1]. The demand for carrot in West Nusa Tenggara (WNT) is predicted to increase, due to an increase in Indonesian population by 1.52% per annum development of WNT as tourism destination and increase nutrition awareness of the community. However, carrot production in WNT was decreased from 2,567 tons in 2016 to 2,043 ton in 2017 and 2,153 tons in 2018 [2]. Therefore, there is a need to increase carrot production, and this may be achieved by extending crop production to the lower lands, since the availability of high lands in WNT is limited.

A successful establishment of carrot plantation in medium latitudes is influenced by selection of suitable variety and plantation technology applied. Many types of carrot are available; however the Nantes-type is preferable by the market due to the shape, texture and taste of the taproot. The Nantes-type carrot has a fine (blunt-end round shape) and a good taste [3]. Several varieties of Nantes-type carrot were reported to be able to grow and produced taproot when cultivated in the lower latitude,
including The New Nantes and the New Kuroda varieties [4,5]. The New Nantes variety is originated from Korea while the New Kuroda variety is originated from Japan. In addition, there are two local varieties which were reported to have high production in high land including the Kirana (Local Cisarua) and Gundaling (Local Berastagi) varieties [6,7]. The Kirana and Gundaling varieties were reported to be able to grow in low latitudes but their yield and yield quality were still low [6,8].

Many investigation suggested that growth and yield of carrot plants were greatly influenced by the type and dose of fertilization applied [9–11], and therefore there is a need to establish suitable fertilization practices to obtain high growth and carrot yield in medium latitudes. Previous studies shown that suitable fertilization strategy for carrot plantation is combination of manure and inorganic fertilization [9–11]. However suitable rate of inorganic (NPK fertilization) is depending on soil fertility, plant variety and other environmental factors in the planting site. This research investigated the responses of different varieties of carrot plant to different dosages of NPK fertilization in medium latitudes at which the chicken manure (20 ton/ha) were added to the soil.

2. Materials and methods
The experiment was conducted in Setiling Village of Central Lombok at altitudes of ca. 650 m above sea level (asl). The experiment was arranged according to Randomized Complete Block design (RCBD) factorial, with 2 factors. The first factor comprised of four carrot varieties: Gundaling (v1), Kirana (v2), New Nantes (v3) and New Kuroda (v4), and the second factor comprised of four dosages of NPK fertilization: 50 kg/ha (r1), 100 kg/ha (r2), 200 kg/ha (r3) and 400 kg/ha (r4). Each treatment was made in triplicated, resulted in 48 experimental plots. Each plot was made as a raised bed of 1 m long x 2 m wide and 0.3 m height. During the plot preparation, chicken manure at the dose of 20 ton/ha (4 kg per plot) and Furadan 3 G (0.004 kg/plot) were mixed with the soil. The carrot seeds were shown by placing seeds in a row of 20 cm, at the depth of ca. 2 cm. Seedlings were thinned at twenty eight day after showing, to an intra-row spacing of 20 cm between plants, and therefore there were 50 plants per plot. The NPK fertilizer was applied twice, at 4 and 8 weeks after showing, half dose per application. The NPK was applied by placing the fertilizer equally between each plant row. Parameters used to investigate plant growth were rate of increase in plant height (obtained from the linear regression of plant height measured every two weeks), rate of increase in the number of leaves (obtained from linear regression of number of leaves measured every two weeks), ratio between above and below ground biomass (fresh above ground biomass/fresh below ground biomass, after harvested), while the parameter for yield were taproot weight per plant, length of taproot, diameter of taproot (top part of taproot), carrot strength and carrot sweetness. All data were analyzed according to Analysis of Variance (Anova) at 5 % confidence level followed by Honest Significant Difference (HSD/Tukey Multiple Range Comparison) at the same confidence level for parameters that were significantly difference according to Anova test.

3. Results and discussion
Growth and yield of carrot were affected by the carrot variety and rate of NPK fertilization applied, but there was no interaction between the carrot variety and NPK fertilization on growth and yield of carrot in medium latitude (Table 1).

The carrot variety influenced the ratio of above and below ground biomass, weight, length and width of taproot, and taproot sweetness while the rate of NPK Fertilization significantly influenced the ratio of above and below ground biomass and taproot weight (Table 1). Growth and yield of different variety of carrot plants at different rate of NPK fertilization in medium latitudes are presented in Table 2, Table 3, Table 4, and Table 5.
Table 1. The summary of Analysis of variance results to show the effect of carrot variety, NPK fertilization and their interaction of growth and yield parameters of carrot grown in medium latitude

| Growth and yield parameter       | Variable | v *) | r  | v x r |
|----------------------------------|----------|------|----|-------|
| Rate of plant height increase    | ns       | ns   | ns |
| Rate of increase in the number of leaves | ns  | ns   | ns |
| Ratio of above and below ground biomass | s    | s    | ns |
| Weight of taproot per plant      | s        | s    | ns |
| Length of taproot                | s        | ns   | ns |
| Diameter of taproot              | s        | ns   | ns |
| Taproot sweetness                | ns       | ns   | ns |
| Taproot texture                  | ns       | ns   | ns |
| Ratio of cortex to stele         | s        | ns   | ns |

*) v: variety; r: dosages of fertilization; ns: non-significantly different, s: significantly different according to analysis of variance at 5% confidential level.

The rate of increase in the carrot plant height and the number of leaves did not significantly influenced by carrot variety and rate of NPK fertilization. When cultivated in the medium latitude, the four carrot varieties examined showed the rate of plant height increase by 5.92 cm/2 weeks to 6.51 cm per weeks and additional of leaves at rate of 1.87 to 2.92 per two weeks. Similarly, the rate of increase in plant height and number of leaves were 5.82 to 6.21 cm/2 weeks and 1.75 to 1.93 leaves/2 weeks respectively, in carrot plant cultivated in the medium latitudes with NPK fertilization between 50 to 400 kg/ha.

Table 2. The rate of increase in plant height and number of leaves as well as the ratio of above and below ground biomass of different variety of carrot plant and rate of NPK fertilization in medium latitude

| Treatment               | Rate of increase in plant height (cm/2 weeks) | Rate of increase in the number of leaves (leaves/2 weeks) | The ratio of above and below ground biomass |
|-------------------------|-----------------------------------------------|----------------------------------------------------------|--------------------------------------------|
| Variety Gundaling       | 5.92                                          | 1.87                                                     | 0.51a *)                                   |
| Variety Kirana          | 6.51                                          | 2.92                                                     | 0.58ab                                     |
| Variety New Nantes      | 5.62                                          | 2.05                                                     | 0.64ab                                     |
| Variety New Kuroda      | 6.21                                          | 2.02                                                     | 0.82b                                      |
| HSD 0.05                | -                                             | -                                                        | 0.29                                       |
| NPK level of 50 kg/ha   | 6.17                                          | 1.76                                                     | 0.62a                                      |
| NPK level of 100 kg/ha  | 6.07                                          | 1.93                                                     | 0.56a                                      |
| NPK level of 200 kg/ha  | 5.82                                          | 1.82                                                     | 0.72ab                                     |
| NPK level of 400 kg/ha  | 6.21                                          | 1.75                                                     | 0.88b                                      |
| HSD 0.05                | -                                             | -                                                        | 0.22                                       |

* ) Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

The ratio of above and below ground biomass at harvest was significantly affected by carrot variety and rate of NPK fertilization. The New Kuroda variety had significantly higher ratio of above and below ground biomass than the Gundaling, Kirana and New Nantes varieties. It means that the New Kuroda variety has more vigorous above ground (leaves and stem) organ than the Gundaling, Kirana and New Nantes varieties. In addition, increasing NPK fertilization was also increase the ratio between above and lower ground biomass, which means that increasing NPK fertilization increased the root and shoot growth of the carrot plant (Table 2).
Table 3. The weight and length of carrot taproots in medium latitude as affected by variety and rate of NPK fertilization

| Treatment               | Weight of taproot/plant (g) | Length of taproots (cm) |
|-------------------------|-------------------------------|-------------------------|
| Variety Gundaling       | 144.80b *)                   | 17.84b                  |
| Variety Kirana          | 128.16ab                     | 18.23b                  |
| Variety New Nantes      | 124.04a                      | 15.62a                  |
| Variety New Kuroda      | 126.33ab                     | 15.34a                  |
| HSD 0.05                | 19.21                        | 2.11                    |
| NPK level of 50 kg/ha   | 121.09 a                     | 16.24                   |
| NPK level of 100 kg/ha  | 112.51 a                     | 16.73                   |
| NPK level of 200 kg/ha  | 138.64b                      | 17.31                   |
| NPK level of 400 kg/ha  | 136.72b                      | 17.22                   |
| HSD 0.05                | 14.64                        | -                       |

*) Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

Table 3 shown that there was a different weight and length of the taproots amongst the four varieties. The New Nantes and new Kuroda had significantly lighter and shorter taproots than the Gundaling variety. The weight of taproots were also influenced by the rate of NPK fertilization, with the higher dosages (200 and 400 kg/ha) resulted in weightier taproots, however different dosages of NPK fertilizer resulted in similar taproot lengths of 16.24 cm to 17.31 cm.

Table 4. The diameter of taproot and taproot sweetness of carrot plant as affected by variety and rate of NPK fertilization medium latitude

| Treatment               | Diameter of taproot (cm) | Taproot sweetness (ºBrix) |
|-------------------------|---------------------------|----------------------------|
| Variety Gundaling       | 4.31a *)                  | 8.92                       |
| Variety Kirana          | 4.12a                     | 8.60                       |
| Variety New Nantes      | 4.24a                     | 8.14                       |
| Variety New Kuroda      | 5.21b                     | 8.25                       |
| HSD 0.05                | 0.96                      | -                          |
| NPK level of 50 kg/ha   | 4.52                      | 8.71                       |
| NPK level of 100 kg/ha  | 4.45                      | 8.59                       |
| NPK level of 200 kg/ha  | 4.66                      | 8.70                       |
| NPK level of 400 kg/ha  | 4.36                      | 8.87                       |
| HSD 0.05                | -                         | -                          |

*) Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

The variety influenced diameter of the taproots (Table 4). The Kuroda variety had significantly wider taproots than the Gundaling, Kirana and New Nantes varieties when cultivated in medium latitude. However, the taproot diameter of carrot plants were not altered by application of NPK fertilization of 50 to 400 kg/ha with diameter ranges between 4.36 cm to 4.66 cm. The taproots sweetness of the four varieties was not significantly different, that were between 8.14 to 8.92 ºBrix. In addition, the taproot sweetness of all carrot plants was not also altered by NPK fertilization at 50 to 400 kg/ha, that were 8.51 to 8.87 ºBrix.

Table 5 showed that all carrot variety and rate of NPK fertilization examined resulted in carrot plant with no different taproot texture (softness). The degree of softness of the four varieties and with application of 50 to 400 kg/ha NPK was between 4.21 to 4.39 kg/cm2 and 4.24 to 4.45 kg/cm2, respectively. The Table 5 also shown that there was a different in the ratio between cortex and style of the taproots amongst the variety, with the Gundaling variety had the highest ratio and the New Kuroda variety had the lowest ratio. However, the ratio between cortex and style of the taproots was not significantly altered by rate of NPK fertilization.
Table 5. The taproot texture and ratio between cortex and stele of carrot plant as affected by variety and rate of NPK fertilization medium latitude

| Treatment                  | Taproot texture/softness (kg/cm²) | Ratio between cortex and stele |
|----------------------------|-----------------------------------|-------------------------------|
| Variety Gundaling          | 4.21                              | 1.82b                         |
| Variety Kirana             | 4.31                              | 1.64ab                        |
| Variety New Nantes         | 4.27                              | 1.62ab                        |
| Variety New Kuroda         | 4.39                              | 1.56a                         |
| HSD 0.05                   | -                                 | -                             |
| NPK level of 50 kg/ha      | 4.31                              | 1.63                          |
| NPK level of 100 kg/ha     | 4.24                              | 1.72                          |
| NPK level of 200 kg/ha     | 4.45                              | 1.58                          |
| NPK level of 400 kg/ha     | 4.32                              | 1.67                          |
| HSD 0.05                   | -                                 | -                             |

*) Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

Together all of the data indicated that there were differences in growth and yield response of the carrot varieties when cultivated in medium latitude. The above ground growth (the rate of increase in plant height, and rate of increase in the number of leaves) were no different amongst the variety, but the Gundaling variety had the highest below ground biomass. In addition, the Gundaling variety also produced the heaviest and longer taproots with higher ratio of cortex although it was slimmer than taproot of the New Kuroda variety.

Carrot is a sub-tropical plant and in the tropics it is commonly cultivated in the highland areas to obtain optimum environmental condition for optimum growth and productivity. In the medium latitudes, the four varieties of carrot examined; Gundaling, Kirana, New Nantes and New Kuroda; were able to grow and produced good quality of taproots. The Kirana (Local Cisarua) variety, New Nantes variety and the New Kuroda variety had been reported previously to be able to grow and produced taproots in lower latitudes [4–6,8], but no comparison was made with the local variety of Gundaling (local Berastagi). This study showed that the local variety of Gundaling had a better yield in medium latitude. The above ground growth of the Gundaling variety was less than the New Kuroda variety, but it has superior below ground growth and yield. These all variety produced good taproots at NPK fertilization of 50 to 400 kg/ha, with a higher yield (weight of taproots) was obtained in NPK fertilization of 200 – 400 kg/ha (no different yield between 200 and 400 kg/ha), in a soil enriched with 20 ton/ha chicken manure. Previous researches has shown that combination of soil organic matters and inorganic fertilization were important to provide better soil physical properties [9], and thus resulted in high yield and high marketable yield of carrot [11,12]. In addition, application of soil organic matter reduced required dosages of inorganic fertilization, from 300 kg/ha to 150 kg/ha [9]. In this study, optimum rate of NPK fertilization in the medium latitude of Setiling village was 200 kg, as shown by yield of taproot (Table 3).

In conclusion, the growth and yield of carrot in medium latitude were significantly influenced by carrot variety and the rate of NPK fertilization applied. The variety influenced the ratio of above and below ground biomass, weight of taproot, tap-root diameter as well as the ratio of cortex to stele in the taproot. The rate of NPK fertilizer influences the ratio of above and below ground biomass and weight of taproot. The highest yield and yield quality was obtained in Gundaling variety, and optimum NPK fertilization was 200 kg/ha. However, there was no interaction between carrot variety and rate of NPK fertilization in influencing growth and yield of carrot plant in the medium latitude.

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