Effect of combination of NPK and nano silica on the levels of β-carotene and nutritional value of corn (Zea mays L.)

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Abstract. Maize plant growth can be improved by the addition of a combination of fertilizer such as nano silica and NPK. Nano silica is a fertilizer that contains micro-nutrients Si which is needed by monocotyl plants to support its growth while NPK fertilizer contains macronutrient such as N, P, and K. NPK fertilizer combination with nano silica aimed at reducing the use of chemical fertilizers but still can improve corn production This study was conducted to determine the effect of optimal combination of nano silica fertilizer and NPK fertilizers in improving the levels of β-carotene and nutritional value of corn (Zea mays L.). Fertilization of nano silica is done by spraying the leaves and stalks of corn plants. NPK fertilizer is given on the edge of the corn crop at a distance of 5 cm from maize, while the dose is given by calculating fertilizer requirement per plant by a dose of fertilizer per plant. There are 5 treatments in this study: P0 (without any fertilizer); P1 (25% nano silica + 75% NPK); P2 (50% nano silica + 50% NPK); P3 (75% nano silica + 25% NPK); P4 (100% nano silica + 0% NPK); P5 (0% nano silica + 100% NPK). Each treatment was repeated 3 times. The parameters of this study consisted of the content of β-Carotene and measured using spectrometry and nutritional value i.e. total carbohydrates, crude protein, crude fiber, fat content, ash content, and moisture content were determined by proximate analyzed. The data were analyzed using Analysis of Variance (ANOVA) if there is a significant difference result can be followed by Duncan Multiple Range Test (DMRT) at the 95% significance level. The results show that the combination of nano silica fertilizer and NPK fertilizer have effects on levels of β-carotene and nutritional value of corn (Zea mays L.). The combined use of NPK fertilizer and nano silica increase beta-carotene and nutritional value compared to corn plants that were not given fertilizer. The most optimal combination of fertilization to maximize the growth of maize is 75% of nano silica fertilizer and 25% NPK fertilizer.

1. Introduction
Corn (Zea mays L.) is an important grain crop in the world. Corn is used primarily in the food industry and in p be animals or as a substrate for biogas stations [1-3], and some countries as 50-55% of source of food. Productivity of corn will be maximized when the irrigation runs smoothly as well as setting the levels of Nitrogen, Phosphorus and Potassium accordingly [2].
In modern agricultural practices where increasing agricultural chemicals, especially fertilizers used for optimum results, it is important to understand the processes involving water and the interaction of nitrogen in the soil and its efficiency in plant growth [4]. Cultivation of superior quality, including corn, highly dependent on adequate and balanced nutrient fertilization [5]. NPK is part of the essential nutrients necessary for the production of meristematic and physiological activities such as leaves, roots, buds, dry matter production, leading to efficient water translocation and nutrition, sun radiation interception and carbon dioxide, which can enhance the process of photosynthesis [6].

Si is a non-essential nutrient that is very beneficial for plants to hold water in a dry environment [7]. In addition, Si is able to bind other nutrients, so that the nutrient content in the soil is not lost, where water and nutrient reserves will also be maintained its quantity [8]. Sufficient supply of Si cereals is able to provide good crop yields because with the addition of Si can increase cell strength and endurance. Supply of Si makes leaves more erect in the effect of high nitrogen fertilization so as to increase photosynthesis[9]. Si plays a role in increasing growth, increasing photosynthesis, transpiration efficiency and evaporation, increasing leaf strength, chlorophyll concentrations per leaf area and product quality [10]. The use of nano-sized Si nano fertilizer (nano silica) will make fertilizers more easily absorbed by plants and more efficient than conventional chemical fertilizers [11].

One of important antioxidant in corn is beta-carotene. Antioxidants that originated from the plant has long been known its potential for stabilizer compound radical that could be measured through the activity of its antioxidants [12]. Moreover, there is an information of analysis composition of proximate and potency antioxidants corn fertilized with combination nano-silica and NPK, because this research aimstodefine beta-carotene content and composition of proximate-21 corn is fertilized with nano silica, NPK, and by combination of both.

2. Methods
The study was conducted from December to June 2016. Planting was done on the land owned by PT Tossa Shakti, Kendal, Central Java Indonesia.

2.1. Tools and materials
The tools used in the research for beta-carotene analysis and proximate. Materials in the form of corn seed varieties P-21 planted with fertilizer treatment nano-silica and given NPK fertilizer with the variation of fertilization as the following:

P0: Control (Without Fertilization);
P1: Combination of nano silica fertilizer 100% and NPK 0% fertilizer;
P2: Combination of 75% nano silica fertilizer and 25% NPK fertilizer;
P3: Combination of 50% nano silica fertilizer and NPK fertilizer 50%;
P4: Combination of 25% nano silica fertilizer and 75% NPK fertilizer;
P5: Combination of 0% nano silica fertilizer and 100% NPK fertilizer.

2.2. β- Carotene analysis and content nutrition
Karsten analysis do with method spectrophotometry with long wave 436 nm while analysis content nutrition form Water Content, Ash Content, Crude Fat, Crude Protein as well Coarse Fiber.

2.3. Analysis of data
The data were analyzed using Analysis of Variance (ANOVA), and in case of significant difference result, can be followed by Duncan Multiple Range Test (DMRT) at the 95% significance level.
3. Methods

3.1. Results analysis of β-carotene ingredients in corn

Results Analysis of β-carotene in maize with combination treatment of Nano silica and NPK fertilizer compared to the control treatment (without fertilizer) shows the results of β-carotene content more widely available in combination treatment Nano silica and NPK fertilizer. The data can be seen in Table 1.

| Treatment | Content of β-Carotene |
|-----------|-----------------------|
| P0        | 0.3638                |
| P1        | 0.4071                |
| P2        | 0.5215                |
| P3        | 0.3353                |
| P4        | 0.3528                |
| P5        | 0.3622                |

Based on Table 1, it can be seen that the highest β-carotene content is found in the treatment of P2 (Nano silica 75%, NPK 25%), it shows that the combination treatment of nano silica and NPK fertilizers is able to increase the β-carotene content better when compared with treatment P0 (control/without fertilizer application), P1 (Nano silica 100%), P5 (NPK 100%).

3.2. Results analysis of β-carotene ingredients in corn

The result of Nutrition Ingredient Analysis on corn with a combination treatment of Nano silica fertilizer and NPK fertilizer show the highest result on parameters of Water Content, Ash Content, Crude Fat, and Crude Protein. In the parameters of the Coarse Fiber, the highest yield is in the treatment of P5 (NPK 100%), whereas in the parameters of Total Carbohydrate and Organic Material without Nitrogen (OMWN) the highest yield is in treatment P0 (control). The data can be seen in Table 2.

| Treatment | Water content | Ash Content | OMWN |
|-----------|---------------|-------------|------|
| P0        | 12.206        | 1.315       | 90.213 |
| P1        | 12.206        | 1.532       | 86.975 |
| P2        | 12.469        | 1.414       | 86.324 |
| P3        | 12.507        | 1.794       | 85.563 |
| P4        | 12.326        | 1.823       | 89.350 |
| P5        | 12.4706       | 1.6514      | 86.808 |

Based on Table 3, it can be seen that P3 treatment (Nano silica 50%, NPK 50%) can increase water content and crude protein in corn. The treatment of P2 (Nano silica 75%, NPK 25%) is able to increase crude fat, P4 treatment (Nano silica 25%, NPK 75%) is able to increase ash content, P5...
treatment (NPK 100%) is able to increase coarse fiber, while P0 (Control) has the highest total carbohydrate and OMWN content.

**Table 3.** Rough fat content, rough fiber, crude protein, and total carbohydrates in maize with a combination treatment of nano silica fertilizer and NPK.

| Treatment | Rough Fat | Coarse Fiber | Crude protein | Total carbohydrate |
|-----------|-----------|--------------|---------------|-------------------|
| P0        | 2.151     | 0.722        | 5.598         | 90.90             |
| P1        | 3.044     | 0.605        | 7.843         | 87.60             |
| P2        | 3.046     | 0.699        | 8.516         | 87.00             |
| P3        | 2.749     | 0.729        | 9.164         | 86.30             |
| P4        | 2.351     | 0.327        | 6.147         | 89.70             |
| P5        | 2.278     | 0.741        | 8.519         | 87.55             |

4. Discussion

The combination treatment of Nano silica and NPK fertilizers is proved to increase the content of β-Carotene, Water Content, Ash Content, Crude Fat, and Crude Protein in corn. This implies that to increase corn productivity, it is necessary to add nano-silica and NPK fertilizer to achieve the optimal result.

Plants that are not fertilized have a wide area leaf lower, this is a reference to the fact that changes in leaf number are related to the overall performance of plants, such as leaf function as an organ of plant photosynthesis [13]. NPK is part of the essential nutrients needed for meristematic and physiological activities such as leaf formation, roots, as, dry matter production, and others, leading to efficient water translocation and nutrition, interception of solar radiation and carbon dioxide. This can improve the process of larger photosynthesis from adequate assimilation to subsequent translocation to various channels [6]. P-acyl grains are significantly influenced by the application of NPK fertilizer. The response pattern is very clear, with the lowest seed yield obtained from the plants treated without fertilizer [14].

Provision of nano silica fertilizer by spraying to its leaves aims to provide silica as a micronutrient element needed by plants which can be absorbed by the plant sufficiently so as to achieve optimal growth. Nanotechnology can be utilized to enhance the ability of plants to absorb nutrients. Nano-sized fertilizers are more readily absorbed and more effective than conventional chemical fertilizers [15]. The plant cell wall acts as a barrier to inserting foreign agents into plant cells, the nanoparticles having a smaller diameter compared with the pore diameter of the cell wall can easily pass through the pores of the walls. The nanoparticles on the leaf surface enter the plant through the pores or villus base and then transported to different tissues [16].

Silicon plays a role in increasing growth, increasing photosynthesis, transpiration efficiency and evaporation, increasing leaf strength, chlorophyll concentration per leaf area and product quality [10]. Nano-silica statistically had a significant effect on carotenoid at probability level (P <0.05). While the control group (without the addition of nano silica fertilizer) has the lowest carotenoids [17]. The use of silicon in cucumbers increases chlorophyll and the activity of leaf photosynthesis, reduces the length of the petiole and increases consistent weight [18].

Increased β-carotene content is associated with an increased process of photosynthesis in corn plants treated with a combination of nano silica and NPK fertilizers. When silica is reduced, the amount of chlorophyll will decrease, the photosynthesis of plants will decrease. Silica has a role in the chain of photosynthesis and prevents chlorophyll degradation by silica. One of the main reasons for the reduction of chlorophyll is its destruction by reactive oxygen species [19]. The reduced activity of photosystem II and Rubisco decreases enzyme activity and ATP inhibition increases the formation of free oxygen species in chloroplasts [20]. Since silica plays an important role in the upright leaf state and is able to provide more areas of leaves to light, thereby increasing the efficiency of plant
photosynthesis [21]. The utilization of nano silica at optimal conditions of tomato growth without stress increased photosynthesis and consistent use of photosynthetic water [22].

Adequate supply of Si in cereal plants is able to provide good crop yields, because with the addition of Si can increase cell strength and endurance. Si supply makes leaves more erect in the effect of high nitrogen fertilization so as to increase photosynthesis. Sufficient use of Si may reduce the likelihood of wilting plants under drought conditions due to decreased permeability of water vapor from leaf epidermal cell walls. It also affects phosphorus fixation so that its availability increases [9].

The treatment of P0 (control) has relatively low β-carotene content because the plant does not get additional nutrients with the addition of nano silica fertilizers, whereas silica has been shown to improve the process of photosynthesis where β-carotene is also formed. Treatment P0 has the highest total carbohydrate and OMWN content although the plant is not given additional nano-silica and NPK fertilizers although not using the addition of NPK fertilizer, this is because the plant can absorb optimally natural nutrients contained in the soil. The use of inorganic fertilizers in plants can improve agricultural yields [23]. Land that is not fertilized by NPK will experience depletion of soil nutrients and reduce agricultural yields. Inorganic fertilizers have a strong effect on growth, development, and yield of plants [24]. The availability of sufficient growth nutrients from inorganic fertilizers leads to increased cell activity, increased propagation and cell enlargement, as well as growth fertility [25]. This shows that to get a good harvest, soil needs additional fertilizer, especially in the corn plant. The lowest tropical soil fertility status inhibits corn production because maize has a very strong grueling effect on the soil. It is generally observed that maize fails to produce good grain in plantings without adequate nutrients [23].

5. Conclusion
The combined use of NPK fertilizer and nano silica increase beta-carotene and nutritional value compared to corn that was not given fertilizer.

The most optimal combination of fertilization is 75% Nanosilicafertilizer and 25% NPK fertilizer which most effectively increases the levels of β-carotene and nutritional value of corn (Zea mays L.).

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