The effect of organic and inorganic fertilizer applications on N, P-uptake, K-uptake and yield of sweet corn (Zea mays saccharata Sturt)

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Abstract. This study was conducted to evaluate the effect of organic fertilizer (i.e. cow manure) and inorganic fertilizer application on nutrient uptake and yield of sweet corn (Zea mays saccharata Sturt). Inceptisols possesses low soil fertility and relatively low to moderate level of organic matter content. Application of organic fertilizer in combination with inorganic fertilizers is expected to increase N, P and K uptake and yield of sweet corn. This study has been conducted from October 2018 to February 2019 at the Field Experiment of Agriculture Faculty, Universitas Padjadjaran, Jatinangor, West Java. The study was performed in a Randomized Block Design consisting of 10 treatments and 3 replications. The treatments were as follow: A = Control, B = Standard NPK, C = 0 NPK + 1 organic fertilizer, D = ¼ NPK + 1 organic fertilizer, E = ½ NPK + 1 organic fertilizer, F = ¾ NPK + 1 organic fertilizer, G = 1 NPK + 1 organic fertilizer, H = ¾ NPK + ¼ organic fertilizer, I = ¾ NPK + ½ organic fertilizer and J = ¾ NPK + ¾ organic fertilizer. The results showed that the treatment I (¾ NPK + ½ organic fertilizer) resulted the highest N, P and K uptake, i.e. 52.11 mg plant⁻¹; 80.85 mg plant⁻¹ and 54.17 mg plant⁻¹, respectively and the heaviest weight of sweet corn of 400.15 g.

1. Introduction
In Indonesia, sweet corn (Zea mays saccharata Sturt) is a very popular vegetable. Annual productivity of sweet corn until 2015 has increased by 3.17% year⁻¹ with rate productivity of 5.18 tons ha⁻¹ and production of 19.61 million tons in 2015. To fulfill lack of supply national production, Indonesia has imported sweet corn from other countries. The annual import rate increased 1.43% until 2015. Meanwhile, the export of sweet corn decreased by 17.25% [1]. The marginal lands in Indonesia which are dominated by Inceptisols soil were abundant. These soil types are potential for future agricultural development [2]. Indonesian Inceptisols have some basic characteristics, such as 1) nutrient status varies from low to high; 2) soil pH from acid to neutral; 3) low to moderate levels of organic material; 4) low to high N and P content ; 5) very low to moderate K, and 6) low to high CEC [3]. The determination of organic fertilizer is one of the solutions to improve the physical and chemical characteristics of acid soils and change the marginal land become more productive.

Fertilization is a method to provide and supply the nutrient of sweet corn. Inorganic fertilization is commonly used by farmers such as the implementation of NPK fertilizer in the form of Urea, SP 36, and KCl. N, P, and K nutrients are essential nutrients for plants, it must always be available in the soil.
The farmers implement fertilization oftenly in an excessive amount. It leads to physical, chemical, and biological damage of soil and decrease soil fertility. Efforts can be made to reduce the negative impact of inorganic fertilizer that can improve soil properties and increase the nutrient content of the soil.

The use of organic inputs such as crop residues, manures and compost has great potential to improve soil productivity and crop yield through the improvement of the physical, chemical and microbiological properties of the soil as well as nutrient supply [4]. If a sustained productive agriculture is an aim, the practices to maintain or increase soil organic matter reserves must be adopted. [5] explained that the agricultural significance of the organic matter in tropical soils is greater than that of any other property, except for moisture. However, the use of organic fertilizers has not been sufficiently explored. The extent to which organic fertilizers could increase the efficiency of applied mineral fertilizers in sustaining soil and crop productivity has not explained much research attention. The integrated plant nutrition involving the combined use of organic and mineral fertilizers increases crop yields more than either used alone [6].

Organic material is required for the growth of the plants. The addition of organic materials from several sources such as manure, green manure, crop residues compost, domestic compost, and industrial residues compost may repair and improve the physical characteristics of the soil. The objective of the research was to investigate the impact of organic fertilizer combined with inorganic fertilizer on N, P and K nutrients uptake and production of Sweet Corn in Inceptisols Jatinangor.

2. Materials and Methods
A field experiment was conducted in Jatinangor, Sumedang District, West Java Province, in Inceptisols with low pH and low in both P and N content. The method used in this research was randomized block design consisting treatments as follows: control (A), NPK recommendation (B), 0 NPK + 2 tons ha\(^{-1}\) organic fertilizer (C), 25% inorganic fertilizer + 2 tons ha\(^{-1}\) organic fertilizer (D), 50% inorganic fertilizer + 2 tons ha\(^{-1}\) organic fertilizer (E), 75% inorganic fertilizer + 2 tons ha\(^{-1}\) organic fertilizer (F), 100% inorganic fertilizer + 2 tons ha\(^{-1}\) organic fertilizer (G), 75% inorganic fertilizer + 0.5 ton ha\(^{-1}\) organic fertilizer (H), 75% inorganic fertilizer + 1 ton ha\(^{-1}\) organic fertilizer (I), 75% inorganic fertilizer + 1.5 tons ha\(^{-1}\) organic fertilizer (J). The recommended dose of inorganic fertilizers was 300 kg ha\(^{-1}\) urea, 100 kg ha\(^{-1}\) SP-36 and 50 kg, ha\(^{-1}\) KCl.

Plant samples were dried out at 65°C to the constant weight and grounded for further analyses. Nitrogen concentration in the plant material was determined by the Kjeldahl method. P concentrations were assessed in ground plant material and mineralized at 550°C for 6 hours. Next, the ash obtained was mixed with diluted HNO\(_3\) (concentrated nitric acid and distilled water 1:1). Phosphorus was determined calorimetrically with vanadium ammonium molybdate. Potassium concentration was assessed by the FAAS method (Flame Atomic Absorption Spectrophotometry). Nutrient uptake was calculated based on dry weight values multiplied by nutrient concentration in plant organs. The sweet corn was harvested at 70 days after planting, and the corn husk was removed. Significant differences among the treatments were calculated using Duncan’s Multiple Range Test (DMRT) at a 5% level of significance.

3. Results and Discussion

3.1. N-Uptake
The results of the variance indicate the method of NPK fertilizer and organic fertilizer affect N uptake. The effect of each treatment was presented in Tables 1.
Table 1. Nutrients Uptake with Organic Fertilizer and Inorganic Fertilizer on Sweet Corn

| Treatment                                      | N-Uptake (mg plant\(^{-1}\)) | P-Uptake (mg plant\(^{-1}\)) | K-Uptake (mg plant\(^{-1}\)) |
|------------------------------------------------|-------------------------------|-------------------------------|-----------------------------|
| A = Control                                    | 12.55 a                       | 46.03 a                       | 18.95 a                     |
| B = Standard NPK                               | 24.34 c                       | 64.34 d                       | 37.25 e                     |
| C = 0 NPK + 1 organic fertilizer               | 14.97 b                       | 54.97 b                       | 24.74 b                     |
| D = ½ NPK + 1 organic fertilizer              | 16.15 ab                      | 56.15 b                       | 25.90 b                     |
| E = ½ NPK + 1 organic fertilizer              | 19.08 b                       | 59.08 c                       | 30.45 c                     |
| F = ¾ NPK + 1 organic fertilizer              | 25.84 c                       | 65.84 d                       | 33.11 c                     |
| G = 1 NPK + 1 organic fertilizer              | 29.84 cd                      | 69.84 e                       | 36.07 d                     |
| H = ¾ NPK + ¼ organic fertilizer              | 31.21 de                      | 71.21 ef                      | 36.61 d                     |
| I = ¾ NPK + ½ organic fertilizer              | 52.11 f                       | 80.85 h                       | 54.17 g                     |
| J = ¾ NPK + ¾ organic fertilizer              | 37.03 e                       | 77.03 g                       | 48.32 f                     |

Numbers in each column followed by a common letter are not significantly different by Duncan’s Multiple Range Test at 5% of significance.

The increased dry weight of the plant is controlled by the ability of the soil to supply the N elements to the rhizosphere to be absorbed by the plant. The increasing ability of the soil to supply N is the access for the provided organic material in providing N for the plant. Organic matter is a source of N, P and S nutrients for plants, so cheap organic matter means increasing the resistance of these elements to plants. The increment of macronutrients in the soil increase the availability of plants absorption, accompanied by the formation of organic compounds in plant tissues [7]. In addition, the volume of photosynthate produced by plants is not only determined by the absorption of sunlight, but also by the level of material in the riboson produced by the absorption of nutrients from the soil. [8] showed that the organic fertilizer in the soil could increase the availability of plant nutrients because of high solubility under acid conditions. [9] reported, the combination between manure with N and P fertilizers increased the availability of soil nutrient, N and P for sweet corn plant. The combination between organic with inorganic fertilizers balance the nutrient status for sweet corn. The result of Duncan’s Multiple Range Test (DMRT) of 5% level (Table 5) showed that the content of ¾ NPK + ½ organic fertilizer increased the N uptake of 52.11 mg plant\(^{-1}\). Increased N plant uptake is associated with an increased dry weight of plants, including improved plant development. This will lead to an increase in the ability of plant roots to absorb air and N in the soil which is a benefit for plant development[7].

3.2. P Uptake
P uptake of maize ranged between 46.03 mg and 80.85 mg plant\(^{-1}\) (Table 1). The combine of Organic fertilizer and inorganic fertilizer was highly significant on P uptake. The highest P uptake of 77.03 mg plant\(^{-1}\) in treatment applied with ¾ NPK + ½ organic fertilizer. Statistically, ¾ NPK + ½ organic fertilizer was significantly different from all other treatments. Increased P uptake of maize is highly determined by the P concentration in the soil. The benefit of organic material is providing plant nutrients so that it can grow and develop properly. According to [10], P uptake is highly determined by root contact with nutrient P, P concentration of soil solution and plant ability.

3.3. K Uptake
As shown in table 1, it can be noticed that the high values of absorbed K by plant tissues recorded with combine NPK + organic fertilizer compared with control treatment. Furthermore, the increment rate of NPK fertilizer increase the quantities of absorbed K element by plant tissues. Table 1 displayed the highest mean value of K uptake by 54.17 mg plant\(^{-1}\) obtained from ¾ NPK + ½ organic fertilizer. Meanwhile, the lowest mean value of K uptake was 18.95 mg plant\(^{-1}\) occurred with the control. The combination ¾ NPK + ½ organic fertilizer application is an efficient treatment to supply K.
3.4. Maize Yield

The components of the observed results include ear of corn weight, the ear of corn diameter and ear of corn length of sweet corn. The results of statistical analysis show the differences in the effect of treatment on the components of sweet corn (Table 2)

| Treatments                        | Ear of Corn Weight (g) | Ear of Corn Diameter (cm) | Ear of Corn Lenght (cm) |
|-----------------------------------|------------------------|---------------------------|-------------------------|
| A = Control                       | 147,33 a               | 3,69 a                    | 22,60 a                 |
| B = Standard NPK                  | 339,00 d               | 5,03 bc                   | 23,13 a                 |
| C = 0 NPK + 1 organic fertilizer  | 159,00 a               | 4,24 ab                   | 22,67 a                 |
| D = ¼ NPK + 1 organic fertilizer  | 216,00 b               | 4,47 abc                  | 23,80 a                 |
| E = ½ NPK + 1 organic fertilizer  | 268,00 c               | 4,64 bc                   | 24,40 b                 |
| F = ¾ NPK + 1 organic fertilizer  | 274,67 c               | 4,71 bc                   | 24,63 b                 |
| G = 1 NPK + 1 organic fertilizer  | 319,00 d               | 4,83 bc                   | 24,53 b                 |
| H = ¾ NPK + ¼ organic fertilizer  | 330,00 d               | 4,93 bc                   | 24,07 b                 |
| I = ¾ NPK + ½ organic fertilizer  | 407,33 e               | 5,43 c                    | 24,60 b                 |
| J = ¾ NPK + ¾ organic fertilizer  | 393,00 e               | 5,13 bc                   | 24,67 b                 |

Numbers in each column followed by a common letter are not significantly different by Duncan’s Multiple Range Test at 5% of significance.

The effect of treatment on the ear of corn weight, ear of corn diameter and ear of corn length component affects the overall result. The ear of corn weight was closely related to the ear of corn diameter and ear of corn length. Long ear of corn with large diameter, and many corn rows will produce large ear of corn weight. The results of the sweet corn crop will increase in line with the nature of the sweet corn. Based on the ear of corn weight, the ear of corn diameter and the ear of corn length, the treatment by using organic fertilizer in combination with NPK showed good results when compared to the treatment of organic fertilizer without NPK.

Based on the statistical analysis ear of corn weight, the highest yield shown by I treatment (¾ NPK + ½ organic fertilizer) but the efficient treatment was on J treatment (¾ NPK + ¾ organic fertilizer) due to non-significant different. The research results show that the use of ¾ NPK + ¾ organic fertilizer recommendation dosage can increase the yield.

4. Conclusions

There was a great increase in yield sweetcorn and yield components, nutrient concentrations of maize crop with the integrated application of organic and inorganic fertilizers relatively different compared to the independently use or the control. The maximum yield sweetcorn and yield components nutrients uptake, the ear of corn weight, the ear of corn diameter and ear of corn length. This experiment showed that the productivity of sweet corn is considerably higher when farmers use integrated soil fertility management options.

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