Effect of soil tillage methods and cattle fertilizer of cow on increasing sweet corn (Zea mays saccharate sturt) production

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Abstract. Sweet corn production is relatively low in Indonesia. To increase production one of the efforts that can be done is to improve the method of soil tillage and by giving doses of cattle fertilizers. The study was conducted in Asam Kumbang Village, North Sumatra Province, Indonesia. The research design used was the Split Plot Design. Treatment factors consist of factors of soil treatment method and factor of cattle fertilizers. The factor of the soil treatment method consists of 3 levels: T1 = No soil tillage. T2 = soil tillage one time. T3 = soil tillage two times. The factor of cattle fertilizers consists of 4 levels: K1 = Inorganic fertilizer/ha (200 kg Urea, 100 kg TSP, 100 kg KCl). K2 = 10 tons of cattle fertilizers/ha. K3 = 20 tons of cattle fertilizers/ha. K4 = 30 tons of cattle fertilizers/ha. The results showed that the highest production of cobs for the treatment of soil tillage methods is found in T2 treatment (soil tillage onetime) with a production level of 8820.19g/plot (26.25 tons/ha). For the treatment of cattle fertilizer, the highest cob production was obtained in K4 treatment (dose of 30 tons of cattle fertilizers/ha) with the production level reached 10154.67g per plot (30.22 tons/ha).

1. Introduction
Sweet corn is one of the important food crop commodities in Indonesia which is generally consumed by residents in the form of boiled corn and mixed vegetables. Sweet corn consumed by residents by buying it other than traditional markets, is also marketed to super market shopping centers and restaurants. Sweet corn production in Indonesia is relatively low at an average of around 2.89 tons of fresh cob per ha. While in other countries such as Australia can reach 7-10 tons of fresh cob per ha [1]. Demand for population needs for this sweet corn commodity continues to increase in line with population growth and the desire to consume it because of its sweet taste and delicious taste. To increase sweet corn production, one of the alternative agronomic measures that can be done is by improving the soil planting media with certain soil treatment methods and by using certain doses of organic fertilizer sourced from cattle fertilizers. It is known that soil tillage is any mechanical manipulation of soil resources needed to create good soil conditions for plant growth. Plant growth mainly influence with good soil treatment, good soil conditions will be obtained from the aspect of soil structure, soil porosity, balance between water, air and temperature in the soil [2]. Therefore, it is absolutely necessary to create a good soil environment in the cultivation of tillage plants. From the entire soil treatment process, there are three factors should be focused. They are: (1) to improve soil physical properties, namely guaranteeing improving soil structure and porosity, so that between water intake and expenditure becomes balanced for plant life. Air circulation in the soil is optimal which will
ensure optimal soil biological activity; to use good planting area in order to support good plant growth; Good processing of the soil allows the circulation of water, air and temperature in the soil to be better for the growth of plants. In order to get good growing of the growth of plants in the planting area influenced by air, temperature and availability of groundwater are needed which can be assisted by the cultivation of the soil; and (3) the use of nutrients in the soil by plants will be easier so that the growth of plants is better. Organic materials as fertilizer ingredients affect soil properties (physical, chemical and biological properties of the soil) and plant growth [2-3].

Organic fertilizer acts as a granulator which is to improve soil structure, macro nutrients and micro elements to plants even though in a low amount, increase the ability of soil to hold water and retain soil nutrients (cation exchange capacity (CEC) of the soil becomes high) as well as source of energy for soil microorganisms so that soil biological activities increase. All plants can grow better if given organic fertilizer. In acid soils organic fertilizer can increase soil pH (neutralize Al by forming Al-organic complexes), and can increase the availability of micro elements in the soil through chelating of micro elements with organic matter [4].

There are nine factors should be considered to get good properties of organic fertilizers on soil fertility. They are (1) organic matter in the mineralization process will release complete plant nutrients (N, P, K, Ca, Mg, S and micro nutrients) in uncertain and relatively small amounts; (2) improving soil structure, causing the soil to become light to be processed and easily penetrated by roots; (3) facilitating the processing of heavy soils; (3) increasing the water holding capacity so that the ability of the soil to provide more water. The moisture of groundwater is more maintained; (4) making soil permeability better; reduce permeability in coarse-textured soils and increase permeability in very soft textured soils (clay); (5) increasing cation exchange capacity (CEC) so that the cation binding ability is higher. As a result, if the soil is fertilized with high doses of organic matter, plant nutrients are not easily washed out; (6) improving the biological life of the soil (both high and low level animals) for the better because food availability is more guaranteed; (7) it can increase buffering capacity against shocks of drastic changes in soil properties; and it contains enough microbes which play a role in the decomposition of organic matter [4].

Organic matter added to the soil would be a source of energy and food for various microorganisms in the soil. Various soil microorganisms become active through the food chain, then undergo a decomposition process to produce various organic and inorganic compounds. These organic and inorganic compounds are pinned or bound by negatively charged clay particles or organic compounds resulting from the decomposition process. These compounds promote plant growth as nutrients and growth regulating compounds [5]. For this reason, it is necessary to conduct a research on how the effects of several methods of tillage and the provision of organic fertilizer from cow pens to increase sweet corn production. The aimed of the study was to find out the best method of tillage and the dosage of manure according to the highest level of sweet corn production.

2. Materials and Methods

2.1. Place and time
The study was conducted in Asam Kumbang Village, Medan Selayang District, North Sumatra Province, Indonesia. Geographic condition of site is relatively flat. The study took place from February to August 2016.

2.2. Materials and tools
Materials used in the study included sweet corn varieties of Bonanza F1, cattle fertilizers, Urea, TSP, KCl and pesticides. While the equipment used consists of a manual hoe, harrow, meter, digital scales, bad luck, callipers etc.
2.3. Research methods
This study used a separate plot design with two treatment factors, namely: (a) factors for treatment of soil processing methods (Main Plot) consist of 3 levels of treatments: (1) $T_1$ = Zero tillage; (2) $T_2$ = Soil tillage one time; and (3) $T_3$ = Soil tillage two times; (b) factors for cattle fertilizers treatment (Sub Plots) consist of 4 levels of treatments: (1) $K_1$ = artificial fertilizer / ha (200 kg Urea, 100 kg TSP, 100 kg KCl); (2) $K_2$ = 10 tons of cattle fertilizers of / ha; (3) $K_3$ = 20 tons of cattle fertilizers/ha; and (4) $K_4$ = 30 tons of cattle fertilizers/ha. The study consisted of 3 replications (blocks) with a total number of treatment plots of 36 plots with the size of each treatment plot 280 cm x 120 cm. The number of sweet corn plants per plot is 24 plants with a total sample of 4 plants per treatment plot. Spacing of sweet corn in the treatment plot is 70 cm x 20 cm. The research data was processed using the Variance Analysis Method (Fisher's test) and the Duncan Multiple Range Test (DMRT) mean difference test at a 5% real test level [6].

2.4. Research implementation
The research began with land clearing by making experimental plots measuring 280 cm x 120 cm as many as 36 experimental plots. The distance between experimental plots is 100 cm and the distance between blocks/replications is 60 cm. The distance between blocks is 60 cm and in each experimental block there are 12 experimental plots. The soil treatment in each experimental plot was carried out in accordance with the treatment of the soil treatment method to be studied, namely $K_1$ = No soil tillage; $T_2$ = Soil tillage onetime; $T_3$ = Soil tillage two times. The experimental plots that have been treated with soil are then applied to cow manure treatment on the experimental plot with four levels of treatment, namely, $K_1$ = Artificial fertilizer/ha (200 kg Urea, 100 kg TSP, 100 kg KCl); $K_2$ = 10 tons of cattle fertilizers/ha; $K_3$ = 20 tons of cattle fertilizers/ha; $K_4$ = 30 tons of cattle fertilizers/ha. Planting sweet corn seeds on the experimental plot was carried out one week after giving cattle fertilizers with a spacing of 70 cm x 20 cm. In each planting hole 2 seeds were planted at a soil depth of about 3 cm and then covered with top soil. Plant maintenance activities during the study consisted of activities of watering plants, planting, weeding, controlling pests and plant diseases, and harvesting yields. Watering plants is done twice a day, namely in the morning and evening if there is no rainy day before. Planting is done when the plant is 2 weeks after planting. For weeding weeds in the experimental plot carried out manually with a hoe tool, carried out once a week. Control of plant pests and diseases is carried out by spraying insecticides Doces 2.5 EC and Ortocide 50 WP fungicides, each with a dose of 1 cc/liter of water. Harvesting results are done when the plants are around 84 days old when the color of corn husk sweet corn is dark green and the tip of the cob looks black and has dried up. Plant parameters observed consisted of root weight, stem diameter, leaf area, ear weight, ear weight per plant plot.

3. Results and Discussion

3.1. Root weight
From the results of data analysis in Table 1, it can be seen that the methods of soil tillage do not significantly affect the parameters of root weight of sweet corn plants, but the application of cow manure has a significant effect ($P<0.05$). Whereas the interaction of the soil tillage methods and cattle fertilizers has no significant effect ($P>0.05$). The root weight of sweet corn assessed here is fresh root weight.

In the provision of cattle fertilizers, the highest root weight parameters of sweet corn plants were found in $K_4$ treatment (30 tons/ha) with a root weight of 20.55 g. However, when compared with $K_1$ treatment, that is by giving Urea 100 kg of artificial fertilizer, 100 kg TSP and 100 kg KCl per ha, it was found that the $K_1$ treatment effect was higher than the $K_4$ effect, where the root weight obtained was 21.77 g. In the provision of cattle fertilizers, the lowest effect on root weights was found in $K_2$ treatment which was 10 tons/ha with root weights obtained at 17.84 g. It is known that organic materials can improve the condition of soil structure so that the soil can become loose, better air
conditioning and groundwater management. This will then have an effect on improving the growth and development of plant roots [4, 7]. On the effect of soil tillage methods on plant root weights there was a tendency of 2 times \( T_3 \) soil tillage method to be higher than other soil tillage methods with plant root weights obtained at 20.62 g. In the interaction effect, the highest root weight was found in the combination treatment of \( T_3 \) and the dosage of \( K_4 \) cattle fertilizers with a root weight of 22.52 g. With good soil conditions will be obtained from the aspect of soil structure, soil porosity, balance between water, air and temperature in the soil. Therefore, in the cultivation of soil tillage plants it is absolutely necessary to create a good soil environment [2].

### Table 1. Fresh root weight (g) in soil tillage method and cattle fertilizer.

| Soil Tillage Methods | Dosage of Cattle Fertilizer (ton / ha) | Average |
|----------------------|--------------------------------------|---------|
|                      | \( K_1 \) (Inorganic Fertilizers)     |         |
|                      | \( K_2 \) (10 ton/ha)                 |         |
|                      | \( K_3 \) (20 ton/ha)                 |         |
|                      | \( K_4 \) (30 ton/ha)                 |         |
| \( T_1 \) (Zero tillage) | 20.40 17.30 17.84 19.12 | 18.66   |
| \( T_2 \) (Soil tillage 1 time) | 21.84 18.08 18.06 20.02 | 19.50   |
| \( T_3 \) (Soil tillage 2 times) | 23.07 18.15 18.74 22.52 | 20.62   |
| **Average**          | 21.77 17.84 18.21 20.55b | 19.60   |

Description: The numbers followed by the same letter on the same line are not significantly different according to DMRT at the level of \( \alpha = 5\% \).

### 3.2. Stem diameter

Based on the results of data analysis in Table 2, it can be seen that cattle fertilizers has a significant effect (\( P<0.05 \)) on stem diameter growth. Whereas the treatment method for soil tillage and interaction of cattle fertilizers and soil tillage methods did not have a significant effect (\( P>0.05 \)) on stem growth parameters.

### Table 2. Diameter of sweet corn stems (mm) in soil tillage methods and cattle fertilizers.

| Soil Tillage Methods | Dosage of Cattle Fertilizer (ton / ha) | Average |
|----------------------|--------------------------------------|---------|
|                      | \( K_1 \) (Inorganic Fertilizers)     |         |
|                      | \( K_2 \) (10 ton/ha)                 |         |
|                      | \( K_3 \) (20 ton/ha)                 |         |
|                      | \( K_4 \) (30 ton/ha)                 |         |
| \( T_1 \) (Zero tillage) | 21.02 19.79 19.59 21.34 | 21.33   |
| \( T_2 \) (Soil tillage 1 time) | 21.59 20.24 20.23 21.01 | 21.01   |
| \( T_3 \) (Soil tillage 2 times) | 22.37 20.23 20.76 21.47 | 21.47   |
| **Average**          | 21.67a 20.08b 20.19b 21.27a | 20.80   |

Notes: The numbers followed by the same letter on the same line are not significantly different according to DMRT at the level of \( \alpha = 5\% \).

The highest stem diameter growth because of the effect of cattle fertilizers dosage on \( K_4 \) treatment which was not significantly different from the \( K_1 \) treatment, each with a stem diameter value of 21.27 mm and 21.67 mm. The lowest stem diameter (20.08 mm) can be obtained at the treatment dose of \( K_2 \) cattle fertilizers. The stem diameter is one important component of plant growth to support good production. With the provision of organic fertilizer, the availability of nutrients needed will be better because cation exchange capacity (CEC) will increase, this will encourage improvements in plant growth and development. In addition, organic materials provide nutrients needed by plants both macro and micro elements [3-4].
3.3. Leaf area

The parameters of leaf area growth based on the results of data analysis in Table 3 are significantly influenced by the treatment of cattle fertilizers. While the treatment of soil tillage methods and their interaction with cattle fertilizers does not have a significant effect on stem diameter growth (Table 3).

Table 3. Leaf area of sweet corn plants (cm$^2$) on soil processing and cattle fertilizer.

| Soil Tillage Methods | Dosage of Cattle Fertilizer (ton / ha) | Average |
|----------------------|----------------------------------------|---------|
|                      | K$_1$(inorganic Fertilizers) | K$_2$ | K$_3$ | K$_4$ |
| T$_1$ (Zero tillage) | 2905.73 | 1989.50 | 2004.20 | 2537.16 | 2359.15 |
| T$_2$ (Soil tillage 1 time) | 2922.09 | 2195.10 | 2393.85 | 2575.32 | 2521.59 |
| T$_3$ (Soil tillage 2 times) | 3689.12 | 2606.07 | 3076.07 | 2833.09 | 3051.08 |
| Average | 3172.31a | 2263.56c | 2491.37bc | 2648.52b | 2643.94 |

Description: The numbers followed by the same letter on the same line are not significantly different according to DMRT at the level of $\alpha = 5\%$.

The highest leaf area because of the effect of cow manure dosage on K$_4$ treatment was 2648.52 cm$^2$, while for K$_1$ artificial fertilizer (3172.31 cm$^2$) the leaf area was higher than the effect of manure. The lowest leaf area is in the treatment of K$_2$ manure dose of 2263.56 cm$^2$. Leaf area is an important component in physiological photosynthesis of plants which will determine the growth, development and production of plants. Leaf development is determined by the supply of nitrogen from the soil. The provision of organic ingredients will supply nitrogen nutrients as well as the provision of artificial fertilizers from Urea fertilizer. Provision of organic ingredients also provides other macro nutrients such as elements of P and K and micro elements. All of this will contribute to the growth and development of plant leaf area [4, 8-9]. The effect of soil tillage methods on leaf area tends to be higher in K$_3$ treatment compared to K$_1$ and K$_2$ treatments. In the combination treatment of soil treatment and the highest dose of manure tends to be found in the combination treatment T$_3$K$_3$ with a value of 3076.07 cm$^2$ leaf area. Whereas K$_1$without organic matter (using inorganic fertilizer) the value of leaf area is 3689.12 cm$^2$. Soil processing will improve the physical condition of the soil both its structure and the condition of the water and air in the soil. This will improve plant growth including the growth and development of leaf area because the growth of plant roots will develop well because it is conditioned by improved soil elasticity, water and air availability [10].

3.4. Cob weight

Based on the results of the data analysis in Table 4 below, it can be seen that the production parameters of cobs weight are significantly affected by the treatment of cattle fertilizer. While the treatment of soil tillage methods and the interaction of soil tillage methods and doses of cattle fertilizers do not have a significantly different effect. The weight of the cob that is included here is the weight of the fresh cob without the cornhusk.

In the treatment of cattle fertilizers, the highest production of cobs weight was found in K$_4$ treatment with cob weight 417.56 g and the lowest was in K$_2$ treatment with cobs weight 248.89 g. It can be seen that the higher the dose of cattle fertilizers given the higher the weight of the cob corn obtained. Cob weights are part of production from the harvest of sweet corn. The provision of cattle fertilizers/organic fertilizer will supplement macro nutrients N, P, K, Ca, Mg, S and micro nutrients needed by plants for the growth and development of crop production components including the production of cob on sweet corn [4, 9-10]. The effect of the highest soil tillage method is found in the T$_2$ treatment with a cob weight value of 364.58 g. With the process of soil tillage method treatment, it will be produced: (1) improving soil physical properties, namely guaranteeing improving soil structure
and porosity, so that between water intake and expenditure becomes balanced for plant life. Air circulation in the soil is optimal which will ensure optimal soil biological activity; (2) growth and development of plants to be good in the planting area including the growth and development of the production of cob on sweet corn crops [2].

Table 4. Weight of sweet corn cobs (g) in soil tillage methods and cattle fertilizer.

| Soil Tillage Method | Dosage of Cattle Fertilizer (ton / ha) | Average |
|---------------------|--------------------------------------|---------|
|                     | K1 (Inorganic Fertilizers) | K2 (10 ton/ha) | K3 (20 ton/ha) | K4 (30 ton/ha) |         |
| T1 (Zero tillage)   | 383.33                          | 236.67        | 270.00          | 356.67          | 311.67b |
| T2 (Soil tillage 1 time) | 430.00                          | 243.33        | 350.00          | 435.00          | 364.58a |
| T3 (Soil tillage 2 times) | 409.00                          | 266.67        | 320.00          | 461.00          | 364.17a |
| Average             | 407.44a                         | 248.89c       | 313.33b         | 417.56a         | 346.81  |

Notes: The numbers followed by the same letter on the same line are not significantly different according to DMRT at the level of $\alpha = 5\%$.

3.5. Weight of Cob/Plot
Cob weights per plot were significantly affected by the treatment of cattle fertilizers and soil tillage methods treatment. While the interaction of cattle fertilizers with soil tillage methods treatment did not give a significantly different effect on the weight of cob per experimental plot (Table 5). In the treatment of cattle fertilizers, the highest production of cobs weight per plot was found in treatment K4 with a production level of mackerel weight obtained at 10154.67 g per plot (30.22 tons/ha). The higher the dose of cattle fertilizers application the higher the cob production per plot obtained. As previously explained that giving cattle fertilizers/ organic fertilizer will supply macro nutrients N, P, K, Ca, Mg, S and micro nutrients needed by plants for the growth and development of crop production components including cob production [4, 9-10].

Table 5. Weight of sweet corn cobs / plots (g) on soil processing and cattle fertilizer.

| Soil Tillage Method | Dosage of Cattle Fertilizer (ton / ha) | Average |
|---------------------|--------------------------------------|---------|
|                     | K1 (Inorganic Fertilizers) | K2 (10 ton/ha) | K3 (20 ton/ha) | K4 (30 ton/ha) |         |
| T1 (Zero tillage)   | 9200.00                          | 5680.00       | 6480.00         | 8960.00         | 7580.00b |
| T2 (Soil tillage 1 time) | 10987.43                         | 5480.00       | 8373.33         | 10440.00        | 8820.19a |
| T3 (Soil tillage 2 times) | 9816.00                          | 6400.00       | 7680.00         | 11064.00        | 8740.00a |
| Average             | 10001.14a                        | 5843.33c      | 7511.11b        | 10154.67a       | 8380.06  |

Notes: The numbers followed by the same letter on the same line are not significantly different according to DMRT at the level of $\alpha = 5\%$.

In the treatment of soil tillage methods, the highest production of cob weight was found in T2 treatment, namely the soil was repulsed once with a production value of 8820.19 g/plot (26.25 tons/ha). With the process of soil tillage treatment, as explained previously, it will be produced: 1. Improving soil physical properties, namely ensuring soil structure and porosity, so that between water intake and expenditure becomes balanced for plant life. Air circulation in the soil is optimal which will
ensure optimal soil biological activity; (2) growth and development of plants to be good in the planting area including the growth and development of the production of cobs on sweet corn crops [2].

4. Conclusions
The research results showed that the highest production of cobs for the treatment of soil tillage methods is found in the treatment of soil tillage one time with a production level of 8820.19 g/plot (26.25 tons/ha). The treatment of cow cattle fertilizer, the highest cob production is obtained in the treatment of 30 tons of cattle fertilizers/ha with the production level reached 10154.67 g/plot (30.22 tons/ha).

References
[1] Ariyanto S E 2011 Perbaikan kualitas pupuk kandang sapi dan aplikasinya pada tanaman jagung manis (Zea mays saccharate Sturt) [Improved quality of cow manure and its application to sweet corn plants] Jurnal Sains dan Teknologi 4 2 p 166
[2] Moenandir H J 2004 Prinsip – prinsip utama cara menyukseskan produksi pertanian.: dasar dasar budidaya tanaman [Principles of Success in agriculture production: basics of plant cultivation] (Malang: Faculty of Agriculture, Universitas Brawijaya)
[3] Mukhlis, Sarifuddin and Hanum H 2011 Kimia tanah: teori dan aplikasi [Soil chemistry: theory and application] (Medan: USU Press.)
[4] Rosmarkam A and Yuwono N W 2002 Ilmu kesuburan tanah [Soil fertility science] (Yogyakarta: Penerbit Kanisius)
[5] Sutanto R 2002 Pertanian organik: Menuju pertanian alternatif berkelanjutan [Organic agriculture: Towards sustainable alternative agriculture] (Yogyakarta: Penerbit Kanisius)
[6] Sastrosupadi A 2007 Rancangan percobaan praktis bidang pertanian [Practical experiment in agriculture] (Malang: Penerbit Kanisius)
[7] Damanik M M B, Hasibuan, B E, Fauzi, Sarifiddin and Hanum H 2011 Kesuburan tanah dan pemupukan [Soil fertility and fertilization] (Medan: USU Press.)
[8] Sutedjo M M 2010 Pupuk dan cara pemupukan [Fertilizer and fertilization method] (Jakarta: Rineka Cipta)
[9] Marschner H 1995 Mineral nutrition of higher plant (London: 2nd Academic Press Harcourt Brace and Company Publishers)
[10] Buckman H O and Brady N C 1982 Ilmu tanah (terjemahan) [Soil science (translation)] (Jakarta: Penerbit Bhratara Karya Aksara)