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IMPROVEMENT OF SOME SOIL CHEMICAL PROPERTIES ON MARGINAL LANDS TO INCREASE CORN PRODUCTION THROUGH CONSERVATION TILLAGE TECHNIQUES AND ORGANIC FERTILIZERS

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Abstract

This study aims to analyze the effect of applying conservation tillage techniques and a combination of organic and inorganic fertilizers on soil chemical properties on marginal land and maize production. This research was conducted in Jambi Outer City District, Muaro Jambi Regency, Jambi Province, from January to April 2021 using a randomized block design with 15 treatments and 3 replications. Parameters observed were corn plant height at the age of 15 DAP, 30 DAP and 45 DAP, weight of corn cobs, weight of dry shelled corn seeds, Soil pH, Soil C-Organic Content, Soil Nitrogen Content, Soil Phosphorus Content, Soil Potassium Content, Cation Exchange Capacity, Base Saturation. The results showed that the application of conservation tillage techniques and a combination of organic and inorganic fertilizers had a significant effect on corn plant height 45 DAP, corn cob weight, soil pH, C-Organic Soil, Soil Phosphorus Content, Soil Potassium Content, Cation Exchange Capacity.

Keywords: Conservation Tillage, Marginal Land, Organic Fertilizer, Soil Chemical Properties

1. INTRODUCTION

The availability of land for agricultural development is increasingly limited, even though land is a dominant production factor that functions as a planting medium. Based on BPS data (2013), Indonesia's land area reaches 191.09 million Ha and 41,919,293 Ha spread throughout Indonesia including Jambi Province is classified as marginal. Based on data from the Center for Agricultural Research and Development (2000), the marginal land area in Jambi Province is 3,449,373 Ha. Therefore, marginal land is an alternative target for developing and increasing agricultural production in Indonesia, including corn (Pawiroharsono, 2012). Although according to Pangli (2016), marginal land has a limiting factor from the aspect of soil fertility.

Corn is an Indonesian food commodity whose production still needs to be increased. Based on BPS data (2019) national corn production is 19,612,435 tons/year. While the demand or need has increased from year to year because corn is a food source that contains carbohydrates and industrial raw materials. Based on BPS data (2019), Indonesia's need for corn reaches 50,18356512 tons/year, so currently Indonesia still imports around 106,5275 tons/year of corn. Jambi Province has a corn production of around 51.712 tons/year. However, the demand is also higher, namely 343,61002 tons/ha.

Extensification policies to increase corn production by utilizing marginal land require land management technology support that can support the supply of nutrients for plants. Fulfillment of plant nutrients that are less available in the soil is generally supplied through both organic and inorganic fertilizers.

Based on the research results of Sharma and Mitra (1991) in Sulaeman & Erfandi (2017), the continuous application of inorganic fertilizers has resulted in an increase in the soil, despite tillage. Based on the research results of Low and Piper (1973) in Hartatik et al. (2015), the use of organic fertilizers can reduce soil density by up to 3%. Therefore, the use of fertilizers can be a combination of inorganic fertilizers and organic fertilizers with the right composition. Tillage techniques consist of conventional tillage techniques and conservation tillage techniques. The selection of tillage techniques must be adjusted to the soil conditions and plant growth requirements. According to research by Rachman (2004) in Adnan et al. (2012), conservation tillage technique is the most effective tillage technique in controlling soil density and increasing fertilization effectiveness.

Based on the above background, this study aims to analyze the effect of applying conservation tillage techniques and a combination of organic and inorganic fertilizers on soil chemical properties on marginal land and corn production in Jambi Luar Kota District, Muaro Jambi Regency, Jambi Province.

2. RESEARCH METHOD

This research was conducted from December 2020 to October 2021 in Pematang Gajah Village, Jambi Outer City District, Muaro Jambi Regency, Jambi Province. The tools used include hoes, scales, sifters, sickles, *gembor*, tape measure, large spray tanks, ropes, machetes, and rakes. The materials used in this study were corn seeds of single cross hybrid variety, rice straw mulch, chicken manure, glyphosate, urea fertilizer, SP-36 fertilizer, KCl fertilizer, chemicals for analysis.

The study was designed in randomized groups with 15 treatments and each treatment was repeated 3 times.

Table 1 Arrangement of Treatment Combinations Between Tillage Techniques, Doses of Organic and Inorganic Fertilizers

Tillage Engineering	**Measurement of Organic and Inorganic Fertilizers**				
	100 % PAnOrg	75 % PAnOrg + 25% PO	50% PAnOrg + 50% PO	25% PAnOrg + 75% PO	100% PO
TOT + Mulch	T1	T2	T3	T4	T5
OTMin + Mulch	T6	T7	T8	T9	T10
OTMax + Mulch	T11	T12	T13	T14	T15

Note: PAnOrg = Inorganic Fertilizer; PO = Organic Fertilizer; TOT = Without Tillage; OTMin = Minimum tillage; OTMax = Maximum Tillage

Prior to the experiment, soil samples were taken compositely at a depth of 0-20 cm. Land preparation was carried out by making 4 m x 6 m experimental plots with a distance

between rows and groups of 50 cm. Each experimental plot was treated with different combinations including: tillage techniques, organic fertilizer application, inorganic fertilizer application, and straw mulching. Furthermore, corn seeds were planted which had previously been soaked in a solution of Acrobat 50 WP fungicide with a concentration of 2 g/liter of water. Plants were maintained by controlling pests and diseases, watering and weeding. If the seeds and cobs had reached the harvest criteria (dried leaves, yellow husks, dry and shiny seeds), then the plants were ready to be harvested. However, before harvesting, soil samples were taken from each experimental plot to determine the chemical properties of the soil in the laboratory.

Data collection was carried out by measuring plant variables and soil variables. Plant variable measurements include:

1) Plant height was measured at the age of 15, 30 and 45 days after planting (DAP) using a meter from the soil surface to the tip (shoot)
2) Cob weight, expressed in grams
3) Weight of dry shelled corn, carried out after drying the shelled corn seeds in the sun. Weighing 1.000 shelled corn with an analytical balance and converting them to tons/hectare.

While the measurement of soil variables includes: pH, C-Organic content, N-total soil, phosphorus content, potassium content, Cation Exchange Capacity (CEC), and Base Saturation (BS). Measurements were made before and after the experiment. Soil variables were determined through analysis in the laboratory.

The effect of treatment on soil chemical properties, plant growth and production were determined through statistical data analysis using analysis of variance at the 95% level of confidence. To differentiate between treatments, data analysis was continued with the DNMRT test at the 95% level of confidence.

3. RESULT AND DISCUSSION

3.1. Soil Properties Before Experiment

Based on the research results, it is known that the soil before the experiment has chemical properties that fall into the moderate to very low category.

Table 2 Soil Analysis Before Research

Soil Properties	Results	Criteria
pH (H2O)	4.59	Acid
N Total (%)	0.09	Very low
C-Organic (%)	1.72	Low
P HCl 25%	10.40	Low
KHCl 25%	45.82	Low
K-dd	0.07	Very low
Ca-dd	0.38	Very low
Mg-dd	0.15	Very low
Na-dd	0.43	Moderate
CEC	4.38	Very low

Source: Bogor Soil Research Institute (2009)

3.2. Effect of Tillage Techniques and Organic Fertilizers on Soil pH Reactions

The results of the analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizers had a significant effect on soil pH. Based on the DMNRT analysis (Table 3) it is known that without tillage and mulch accompanied by 100% dose of inorganic fertilizer (T1 treatment) is the best treatment to improve soil pH. Although it showed no difference with the T12, T13, T14, T15 and T2 treatments. The T1 treatment was considered more effective, especially from the type of tillage used. This is presumably because the process of decomposition of organic matter in land without tillage and maximum tillage releases organic acids, causing the soil to be slightly acidic compared to minimum tillage techniques.

Table 3 Analysis of Variance of Conservation Tillage Techniques and Organic Fertilizers to pH Soil

Plot	pH Soil
T1	5.893 b
T2	5.190 b
T3	4.617 a
T4	4.487 a
T5	4.517 a
T6	4.453 a
T7	4.380 a
T8	4.330 a
T9	4.593 a
T10	4.663 a
T11	4.543 a
T12	5.460 b
T13	5.647 b
T14	5.653 b
T15	5.603 b

Note: Numbers followed by different letters show significantly different according to Duncan's α 5% multiple range test

3.3. Effect of Tillage Techniques and Organic Fertilizers on C - Organic

The results of the analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizers had a significant effect on soil organic C. Based on DMNRT analysis (Table 4) it is known that maximum tillage and mulching accompanied by 50% dose of inorganic fertilizer and 50% dose of organic fertilizer (T13) is the best treatment for improving Soil Organic C. Although it did not show any difference with the T14 and T15 treatments.

T13 treatment with the maximum type of tillage had an effect on increasing the decomposition of soil organic matter. Soil processing, crop residues, organic and inorganic materials applied to the soil simultaneously affected the activities of soil organisms. The results of research by Pankhurst and Lynch (1993) in Herdiyanto & Setiawan (2015) proved that tillage would spur the development of aerobic microbes that have high metabolism resulting in the development of bacteria-eating fauna on agricultural soils, so that the decomposition of organic matter and nutrient mineralization increased rapidly.

Table 4 Analysis of variance of Conservation Tillage Techniques and Organic Fertilizers on Soil Organic C-Content

Plot	C - Organic	
T1	1.30	b
T2	1.46	b
T3	1.09	a
T4	0.89	a
T5	0.50	a
T6	0.50	a
T7	0.50	a
T8	0.50	a
T9	0.50	a
T10	1.08	a
T11	1.32	b
T12	1.75	b
T13	2.36	c
T14	2.15	c
T15	2.19	c

Description: Numbers followed different letters indicate significantly different according to Duncan α 5% multiple range test

3.4. Effect of Tillage Techniques and Organic Fertilizers on Soil Total N

The results of the analysis of variance showed that tillage techniques and combinations of inorganic and organic fertilizers had no significant effect on N Total Soil. Based on DMNRT analysis (Table 5) it is known that without tillage and mulch accompanied by 75% dose of inorganic fertilizer and 25% organic fertilizer (T2) is the best treatment for improving Soil Total N.

Table 5 Analysis of Variety of Conservation Tillage Techniques and Organic Fertilizers on Soil Total Nitrogen Content

Plot	N – Total	
T1	0.043	a
T2	0.080	a
T3	0.067	a
T4	0.070	a
T5	0.043	a
T6	0.043	a
T7	0.037	a
T8	0.057	a
T9	0.060	a
T10	0.053	a
T11	0.057	a
T12	0.057	a
T13	0.060	a
T14	0.050	a
T15	0.053	a

Description: Numbers followed different letters indicate significantly different according to Duncan α 5% multiple range test

At maximum tillage, the soil is processed perfectly which causes the soil to become loose so that the soil aeration becomes good and nutrients in the soil are easily washed away by rainwater. At minimum tillage and without tillage the soil experiences compaction (hardness) so that soil aeration conditions are not good and the plant's ability to fix N in the air is reduced. According to Sutedjo (2010) the low nitrogen content is caused by the much needed nitrogen nutrient, and its presence in the soil is very mobile so it is easily lost through washing, erosion, transported by plants and evaporation.

3.5. Effect of Tillage Techniques and Organic Fertilizers on Soil Phosphorus Content

The results of the analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizers had a significant effect on the soil phosphorus content. Based on DMNRT analysis (Table 6) it is known that minimum tillage and mulching accompanied by 50% dose of inorganic fertilizer and 50% dose of organic fertilizer (T8) is the best treatment for improving soil Phosphorus. Although it showed no difference with the T4, T5, T9, T11 and T15 treatments.

Table 6 Analysis of variance of Conservation Tillage Techniques and Organic Fertilizers on Soil Phosphorus Content

Plot	P - Available	
T1	7.84	a
T2	8.92	a
T3	7.21	a
T4	11.99	b
T5	9.24	a
T6	7.79	a
T7	9.22	a
T8	14.83	b
T9	14.28	b
T10	8.21	a
T11	10.97	b
T12	8.76	a
T13	4.98	a
T14	7.11	a
T15	10.33	b

Description: Numbers followed different letters indicate significantly different according to Duncan α 5% multiple range test

T8 treatment is considered more effective. Minimum tillage slows down the mineralization process, so that the use of nutrients in organic matter is more sustainable than maximum and no tillage techniques. The results research of Stevenson (1982), the availability of P in the soil can be increased by adding organic matter through a mineralization process that releases P minerals, organic matter will reduce phosphate uptake because humid acid and fulvic acid function to protect sesquioxide's by blocking exchange sites. The research results of Burhannudin (2015) proved that P is an immobile element, meaning that phosphorus will remain in the top layer if it is not mechanically introduced into the deeper layers, the lack of tillage causes phosphorus to remain accumulated above the soil

surface, so that it will be lifted more when erosion occurs. This resulted in a higher concentration of phosphorus in minimum tillage.

3.6. Effect of Tillage Techniques and Organic Fertilizers on Soil Potassium Content

The results of the analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizer doses had no significant effect on soil potassium content. Based on DMNRT analysis (Table 7) it is known that without tillage and mulching accompanied by 25% dose of inorganic fertilizer and 75% dose of organic fertilizer (T4 treatment) is the best treatment for improving soil Potassium.

Table 7 Analysis of variance of Conservation Tillage Techniques and Organic Fertilizers on Soil Potassium Content

Plot	K - dd	
T1	0.11	a
T2	0.19	a
T3	0.21	a
T4	0.46	a
T5	0.42	a
T6	0.24	a
T7	0.25	a
T8	0.26	a
T9	0.30	a
T10	0.30	a
T11	0.11	a
T12	0.17	a
T13	0.12	a
T14	0.16	a
T15	0.25	a

Description: Numbers followed different letters indicate significantly different according to Duncan α 5% multiple range test

Although not significantly different from other treatments. The initial K content before the soil was cultivated was very low, namely 0.07 cmol+/kg. In the T4 treatment with 75% organic matter, the K content was higher than the other treatments. Element K in the soil decomposes slowly, so that the residue of element K can be greater in the soil (Nurahmi, 2010 in (Agsari et al., 2020)).

3.7. Effect of Tillage Techniques and Organic Fertilizers on Cation Exchange Capacity (CEC)

The results of the analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizers had a significant effect on the Cation Exchange Capacity (CEC). Based on the DMNRT analysis (Table 8) it is known that maximum tillage and mulching accompanied by 25% doses of inorganic fertilizers and 75% doses of organic fertilizers (T14 treatment) are the best treatments to improve the cation exchange capacity of the soil. Although it showed no difference with the T4, T5, T6, T8, T9, T11 and T15 treatments.

The T14 treatment was considered more effective. The CEC is directly dependent on the amount of charge in the soil colloid, soil texture, and soil organic matter content. The research results of Kautsar et al. (2018) proved that the application of manure can increase the capacity of cation exchange. Soil organic matter that undergoes decomposition produces organic compounds that have functional groups and increase the negative charge thereby increasing the cation exchange capacity of the soil.

Table 8 Analysis of variance of Conservation Soil Tillage Techniques and Organic Fertilizers on Cation Exchange Capacity (CEC)

Plot	CEC	
T1	11.59	a
T2	14.52	a
T3	15.22	a
T4	16.01	b
T5	17.05	b
T6	16.70	b
T7	13.07	a
T8	15.99	b
T9	17.00	b
T10	14.76	a
T11	16.96	b
T12	13.82	a
T13	13.81	a
T14	17.57	b
T15	15.83	b

Description: Numbers followed different letters indicate significantly different according to Duncan α 5% multiple range test

3.8. Effect of Tillage Techniques and Organic Fertilizers on Base Saturation

The results of the analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizers had a significant effect on soil base saturation. Based on DMNRT analysis (Table 9) it is known that without tillage and mulch accompanied by 50% dose of inorganic fertilizer and 50% dose of organic fertilizer (T3) is the best treatment. Although it showed no difference with the T1, T2, T5, T11 and T15 treatments. The T3 treatment was considered better, especially from the organic matter given. Manure is able to fulfill soil nutrients, because it contributes to soil solubility cations. The results of research by Taisa et al. (2021) proved that the addition of organic matter and inorganic fertilization will add soil nutrients such as nitrogen, phosphorus, sulfur, potassium, boron, etc. so that Base saturation increases.

Table 9 Imprint Analysis of Conservation Soil Tillage Techniques and Organic Fertilizers on Base Saturation

Plot	Base Saturation (BS)
T1	0.18b
T2	0.18b
T3	0.20b

T4	0.18a
T5	0.18b
T6	0.17a
T7	0.16a
T8	0.15a
T9	0.14a
T10	0.16a
T11	0.18b
T12	0.15a
T13	0.14a
T14	0.13a
T15	0.18b

Description: Numbers followed different letters indicate significantly different according to Duncan α 5% multiple range test

According to Tan (1991) in Sugama et al. (2015), soil base saturation ranging from 50% - 80% is classified as having moderate fertility and is said to be infertile if it is less than 50%. This shows that the soil after the research has undergone further leaching and/or the soil originates from base-poor parent material. Research results by Quideau (1999) in Jagau & Neneng (2012) proved that the biological cycle of plants transports nutrients through leaves, twigs, and other plant residues, then is returned to the soil surface or near the mineral soil surface as waste.

3.9. Effect of Applying Tillage Techniques and Organic Fertilizers to Corn Plant Height

The results of the analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizers had a significant effect on the height of the corn plants at 15 DAP, 30 DAP and 45 DAP. Based on DMNRT analysis (Table 10) and figure 2, it is known that at 15 days after planting, without tillage and mulch accompanied by 100% dose of organic fertilizer (T5 treatment) is the best treatment to provide the highest growth in corn plant height of 33,2 cm compared to treatment others, but significantly different from the treatments T1, T6, T11, T7, T2, T12, T10, T3, T4, T8, T15, T13, T19 and T14. At 30 days after planting, maximum tillage and mulching accompanied by 50% dose of inorganic fertilizer and 50% dose of organic fertilizer (T13 treatment) gave the highest growth in height of corn plants compared to other treatments but not significantly different from the T12, T8, T4 and T9 treatments. At 45 days after planting, maximum tillage and mulch accompanied by 25% dose of inorganic fertilizer and 75% dose of organic fertilizer (T14 treatment) gave the highest growth in height of corn plants compared to other treatments, but not significantly different from treatments T12, T9, T8, T13 and T14.

Tillage treatment had a significantly different effect on plant height at 15, 30 and 45 DAP. The treatment without tillage (T1) had the lowest plant height because the soil had a dense soil structure so that the roots were less developed to go deeper at the beginning of the growth period so that the uptake of nutrients from the soil was hampered, while the maximum tillage (T13 and T14) has the highest plant height value compared to other tillage methods because tillage is done perfectly, namely turning the soil back and forth so that there are many cavities or pore spaces for the corn plant root zone to go deeper to take up nutrients.

The research results of Hadianto et al. (2019) prove that a perfect tillage system can give better yields to corn plants. This situation is caused by the sweet corn plant has a wider distribution of roots. Good tillage causes a decrease in the level of soil penetration resistance.

The treatment without organic fertilizers had the lowest plant height values (T1 and T6) and the treatments using organic fertilizer doses of 100%, 75% and 50% had the highest plant height values. This can happen because organic fertilizers help improve the physical, chemical and biological structure of the soil so that the soil becomes fertile and organic fertilizers can help the absorption of nutrients in the soil by plants. Organic fertilizers have nitrogen levels which fertilize the soil and are assisted by biological activity in the soil so that the absorption of nutrients in the soil can be absorbed optimally at doses of organic fertilizers of 100%, 75% and 50%.

Table 10 Corn Plant Height (cm) with Conservation Tillage Technique and Organic Fertilizer

Plot	Plant height (cm)		
	15 DAP	30 DAP	45 DAP
T1	28 a	79.5 a	119.8 a
T2	31.2 b	101.7 d	160.8 d
T3	32.2 c	105.8 d	167.5 e
T4	32.2 c	108.5 e	168.3 e
T5	33.2 d	101.5 d	169 e
T6	28.8 a	87.5 b	127.7 b
T7	30.7 b	103.3 d	176.2 f
T8	32.2 c	108.2 e	180.5 g
T9	32.5 c	109.8 e	179.7 g
T10	31.9 b	100.3 d	173.8 f
T11	29.7 a	89.7 c	134.2 c
T12	31.4 b	107.5 e	178.7 g
T13	32.3 c	111.2 e	181.3 g
T14	32.7 c	106.5 d	183.2 g
T15	32.2 c	100.3 d	177.2 f

Note: Numbers followed by different letters show significantly different according to Duncan's α 5% multiple range test

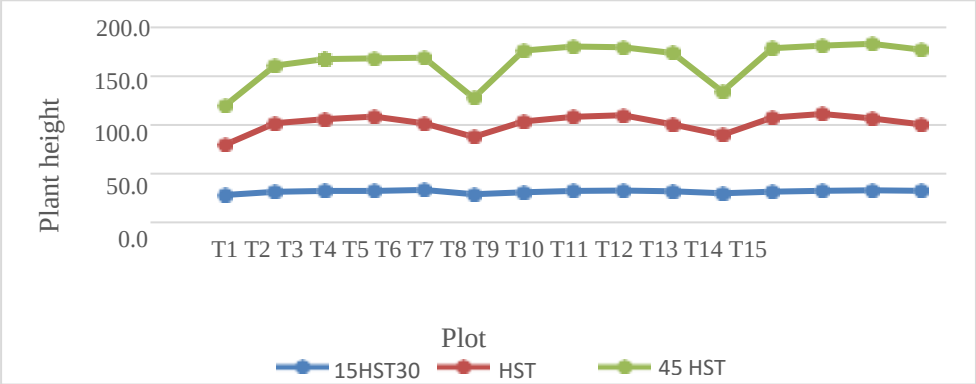

Figure 1 Corn Plant Height (cm) with Conservation Tillage and Fertilizer Techniques organic

3.10. Effect of Applying Tillage Techniques and Organic Fertilizers to the Weight of Corn Cobs

The results of the analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizers had a significant effect on the weight of corn cobs. Based on DMNRT analysis (Table 11) it is known that without tillage and mulching accompanied by 25% dose of inorganic fertilizer and 75% dose of organic fertilizer (T4 treatment) is the best treatment for corn cob weight. Although it showed no difference with the T3, T5, T7, T8, T9, T10, T12, T13 and T15 treatments. The T4 treatment was considered more efficient, especially in terms of the organic matter used.

This happens because organic fertilizers are useful in providing macro and micro nutrients for plants, facilitating root growth and longer water absorption in the soil, increasing the growth and production of corn, especially the growth of corn cobs and seeds. Research results by Sihaloho & Sipayung (2019) prove that the application of organic fertilizers can increase the availability of water in the soil so that it can increase corn production, because enough water is needed to form seeds. Lack of water causes the flowers to fall and inhibits seed formation

Table 11 Weight of Corn cob (grams) with Conservation Tillage Technique and Organic Fertilizer

Plot	Corn cob weight (gram)	
T1	137.2	a
T2	193.8	a
T3	230.9	b
T4	279.5	b
T5	240.2	b
T6	152.8	a
T7	223.7	b
T8	236.9	b
T9	220.7	b
T10	269.8	b
T11	181.9	a
T12	216.1	b
T13	230.7	b
T14	258.9	b
T15	265.6	b

Note: Numbers followed by different letters show significantly different according to Duncan's α 5% multiple range test

3.11. The Effect of Applying Tillage Techniques and Organic Fertilizers to Shelled Corn Weight

The results of analysis of variance showed that the type of tillage technique and the combination of inorganic and organic fertilizers had a significant effect on shelled corn weight. Based on the DMNRT analysis (Table 12) it is known that minimum tillage and mulching techniques accompanied by 50% doses of inorganic fertilizers and 50% doses of organic fertilizers (T8 treatment) are the best treatments for Shelled Corn Weight. This is

because the T8 treatment contains the availability of ground water from the decomposition of 50% organic fertilizer and 50% chemical fertilizer into soil organic matter that can be utilized in the process of filling shelled corn. Research Results of Rachman A, Dariah (2004) proved that minimum tillage can reduce evaporation and increase infiltration which causes the soil water content to be higher around the root areas of maize plants compared to intensive tillage, so that the crop yield (total dry weight of all plants) of maize will be higher in minimum tillage treatment.

Table 11 Dry shelled corn (grams) with Conservation Tillage Technique and Organic Fertilizer

Plot	Corn cob weight (gram)	
T1	168.7	**a**
T2	212.8	a
T3	217.0	a
T4	268.7	b
T5	287.2	b
T6	217.2	a
T7	235.2	b
T8	315.8	c
T9	296.9	b
T10	273.7	b
T11	270.7	b
T12	256.6	b
T13	272.1	b
T14	279.8	b
T15	289.0	b

Note: Numbers followed by different letters show significantly different according to Duncan's α 5% multiple range test

4. CONCLUSION

Conservation tillage techniques and the combination of organic and inorganic fertilizers affect some of the chemical properties of the soil and corn yields on marginal lands. The best influence on soil chemical properties (specifically N total soil, soil phosphorus content, soil potassium content, and CEC) on corn production is seen with application without tillage with a dose of 25% inorganic fertilizer and 75% organic fertilizer (T4).

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