The application of Hydrogel (Super Absorbent Polymer) and chicken manure fertilizer to increase pH, N-total, C-organic and soil water content in Entisol

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Abstract. Entisol is one of the soils which not only poor in nutrients, especially Nitrogen and organic carbon, but also has an acidic pH and low water-holding power due to the sandy soil fraction hence additional soil conditioners are needed to improve the soil, such as hydrogel and chicken manure as organic material. This research aimed to assess the ability of hydrogel and chicken manure to increase pH, N-total, C-Organic and moisture content in Entisol soil. The research was conducted in a greenhouse using a randomized block design with 2 factors, factor I was the hydrogel consisting of H0 = 0 g/polybag, H1 = 100 g/polybag, H2 = 200 g/polybag, H3 = 300 g/polybag and factor II was chicken manure consisting of K0 = 0 g/polybag, K1 = 50 g/polybag, K2 = 100 g/polybag, and K3 = 150 g/polybag. The results showed that the hydrogel and chicken manure and its interaction were able to increase the pH, N-total, C-organic and soil water content of Entisol.

1. Introduction
Entisol is one of the marginal land groups in Indonesia with an area of ± 18,006,000 ha or about 9.6% of the total land area in Indonesia with the widest distribution in Papua, followed by Sumatra and Kalimantan, hence the opportunity for extensification is still widely open [1]. Entisol soil is coarse-textured or dominated by a sand fraction, has a loose consistency, loose structure, low level of aggregation, sensitivity to erosion and low nutrient content and also low organic matter. Sandy soil is very porous hence the water and fertilizer buffer capacity is very low, poor in nutrients and does not support plant growth. Entisol is generally poor in sufficient quantities of N, P and K but have not rotted and are not ready for plant absorption.

Hydrogel has recently been widely used in various sectors, both in the food and non-food sectors, one of which is disposable diapers. Hydrogel (super absorbent polymer) in baby diapers consists of sodium polyacrylate (C3H3NaO2) granules derived from petroleum [2]. A hydrogel can absorb and retain liquid up to 100 times it is mass. Used hydrogel in baby diapers also contains urine which can be used as a soil conditioner and can supply nitrogen because urine generally contains ammonia (NH3). According to [3], hydrogel from baby diaper waste can be used as water-absorbent in agriculture for better irrigation management. The addition of hydrogels can restore soil, reduce water loss and can increase plant growth.

Apart from hydrogels, chicken manure can also be used to improve soil properties. Chicken manure contains quite-high N nutrient compared to other manure, which is 1.27 %. The use of organic matter in the form of manure can increase soil C-organic and the ability of the soil to support cations...
because the result of organic matter decomposition is to produce a complex compound called humus \[4\]. Therefore, it is necessary to research to assess the potential of hydrogels and chicken manure in increasing pH, N availability, C-organic and soil water content in Entisol. This research aimed to assess the ability of hydrogel and chicken manure to increase pH, N-total, C-organic and soil water content in Entisol.

2. Materials and methods

The research was conducted in the Greenhouse. Soil analysis was at the Research and Technology Laboratory of Faculty of Agriculture, University of Sumatera Utara and at the Laboratory of Sumatera Utara Assessment Institute for Agricultural Technology (AIAT) from October 2019 to February 2020. The soil sample used was Entisol soil taken from Sidodadi village, Beringin sub-district, Deli Serdang districts, the hydrogel was from used baby diapers by the Merries®, and packed chicken manure from Riski Kompos brand. This research used the randomized block design with 2 factors and 3 replications. Factor I: Hydrogel dose (H) consists of four levels, namely H0 = 0 g/polybag, H1 = 100 g/polybag, H2 = 200 g/polybag, and H3 = 300 g/polybag. Factor II: Chicken manure dose (K) consisted of 4 levels, namely K0 = 0 g/polybag, K1 = 50 g/polybag, K2 = 100 g/polybag, and K3 = 150 g/polybag. The further test used the Duncan Multiple Range Test at 1 and 5%. The plant medium of 10 kg of air-dried soil was put in a polybag, and then the hydrogel and chicken manure were applied according to the appropriate treatment and incubated for 4 weeks with field capacity conditions. Parameters measured were pH-H2O 1:2 (electrometry), N-total (Kjeldahl), C-organic (Walkley and Black) at 4 weeks after treatment application and soil moisture content (gravimetric) at 0, 4 and 8 weeks after treatment application.

3. Results and discussion

3.1. Soil pH

Based on the data by analysis of variance on soil pH showed that the application of hydrogel and chicken manure and their interactions had a significant effect. These results were presented in table 1.

| Hydrogel (g/polybag\(^-1\)) | Chicken Manure Fertilizer (g/polybag\(^-1\)) | Mean       |
|-----------------------------|-------------------------------------------|------------|
| 0                           | (0)                                       | 4.69 ff    |
|                             | (100)                                     | 5.37 ff    |
|                             | (200)                                     | 5.55 defcdef |
|                             | (300)                                     | 6.07 bab   |
|                             | Mean                                      | 5.42 cc    |

Information: Numbers in rows and columns followed by the same letter are not significantly different at the 5% and 1% levels according to the DMRT.

The data showed that the application of hydrogel and chicken manure and their interactions had a highly significant effect on increasing soil pH from acid to slightly acid criteria. The highest pH was found in a combination of 300 g hydrogel and 150 g chicken manure /polybag. The increasing pH due to the chicken manure and hydrogel were organic matters in which the decomposed organic matter was able to produce organic acids in the form of humid acid and fulvic acid which played an important role in reducing Al hence the production of H\(^+\) ions as a result of the hydrolysis of Al will decrease \[5\]. Hydrogel has carboxyl groups (-COOH) and Na\(^+\) cations hence it can increase soil pH. According to \[6\], it was identified that all hydrogel incubation treatments increased the pH in the soil compared to the 0 g hydrogel (control) by a range of 4 to 8 percent. The negative charge arises from the
dissociation of H+ from the hydrogel, other cations including functional groups had risen to the surface, thereby neutralizing the cation exchange site and causing an increase in soil pH.

### 3.2. Soil total N

The application of hydrogel and chicken manure and their interactions significantly affected the Soil Total N and these results were presented in table 2.

#### Table 2. The soil total N value due to the hydrogel and chicken manure application

| Hydrogel (g.polybag⁻¹) | Chicken manure fertilizer (g.polybag⁻¹) | Mean % |
|------------------------|----------------------------------------|--------|
| (0)                    | 0.08 f d                               | 0.09 cc|
| (100)                  | 0.09 ef cd                             | 0.12 bbc|
| (200)                  | 0.10 cdef cd                           | 0.14 cd |
| (300)                  | 0.09 ef cd                             | 0.15 bbbc|
| Mean                   | 0.09 cc                                | 0.12 bbc|

Information: Numbers in rows and columns followed by the same letter are not significantly different at the 5% and 1% levels according to the DMRT.

In table 2, it can be seen that the application of hydrogel and chicken manure and their interactions can increase the soil total N content with the highest value in 200 g hydrogel and 150 g chicken manure from very low to moderate criteria. The increase of total N in soil because hydrogels in baby diapers absorb urine containing NH₃ which is a source of nitrogen in the soil and will be absorbed by plants after going through the ammonification and nitrification processes [7]. The urine is absorbed by the hydrogel will be released at the same time as the hydrogel decomposes and it takes about 4 weeks for hydrogel to wear out. According to [8] 10 ton/ha chicken manure was able to increase the soil total N from 0.32% to 0.53%.

### 3.3. Soil C-organic

Table 3 showed that chicken manure application can increase soil C-organic but the hydrogel application did not any significant effect. The interaction between the hydrogel and chicken manure had the best effect with 200 g hydrogel and 150 g chicken manure and the same effect with 300 g hydrogel and 100 g chicken manure to increase soil C-organic from very low to low criteria.

#### Table 3. Soil C-organic values due to the hydrogel and chicken manure application

| Hydrogel (g.polybag⁻¹) | Chicken manure fertilizer (g.polybag⁻¹) | Mean |
|------------------------|----------------------------------------|------|
| (0)                    | 0.60 e                                 | 0.91 |
| (100)                  | 0.63 e                                 | 0.98 |
| (200)                  | 0.80 de                                | 1.07 |
| (300)                  | 1.06 cde                               | 1.16 |
| Mean                   | 0.77 cd                                | 1.34 aa|

Information: Numbers in rows and columns followed by the same letter are not significantly different at the 5% and 1% levels according to the DMRT.
The increase of C-organic in Entisol soil occurred due to the addition of organic matter, the main constituent is carbon compounds hence it will add C-organic in the soil [9]. The C-organic content contained in organic matter is between 48% -58% of the total weight of organic matter [10].

3.4. Soil water content
The application of hydrogel and chicken manure and their interactions significantly affect soil water content at 0, 4 and 8 weeks after application as shown in table 4, 5, and 6.

Table 4. The value of soil water content due to the hydrogel and chicken manure application at 0 week after application

| Hydrogel (g.polybag⁻¹) | Chicken manure application (g.polybag⁻¹) | Mean |
|------------------------|------------------------------------------|------|
|                        | (0)                                      | (50) | (100) | (150) | % |
| (0)                    | 7.51 gf                                  | 7.65 gf | 7.75 gf | 8.75 gf | 7.92 cd |
| (100)                  | 8.74 gf                                  | 8.95 fgef | 11.88 cdefcdef | 12.06 cdcd | 10.41 bbc |
| (200)                  | 9.03 efgdef                              | 10.30 defgdef | 10.94 cdefcdef | 12.10 cc | 10.59 bb |
| (300)                  | 10.90 cdefgdef                           | 11.99 cedcde | 17.73 bb | 20.23 aa | 15.21 aa |
| Mean                   | 9.04 cc                                  | 9.72 bcc | 12.07 abb | 13.29 aa | 15.55 |

Information: Numbers in rows and columns followed by the same letter are not significantly different at the 5% and 1% levels according to the DMRT

In Table 4, it can be seen that the higher dose of hydrogel and chicken manure dose caused the higher water content in the soil. The highest increase in soil water content was found in 300 g hydrogel/polybag but 100 g and 200 g hydrogel/polybag not significantly affect. The highest soil water content due to the application of chicken manure was found in the 150 g chicken manure/polybag and the highest soil water content was found in 300 g of hydrogel and 150 g of chicken manure interaction.

Table 5. The value of soil moisture/water content due to the hydrogel and chicken manure application at 4 weeks after application

| Hydrogel (g.polybag⁻¹) | Chicken manure fertilizer (g.polybag⁻¹) | Mean |
|------------------------|-----------------------------------------|------|
|                        | (0)                                      | (50) | (100) | (150) | % |
| (0)                    | 7.78 gf                                  | 7.72 gf | 8.57 gf | 9.06 gf | 8.28 cd |
| (100)                  | 9.85gf                                  | 10.21fgef | 11.41cdefcdef | 11.80 cdefcdef | 10.82 bc |
| (200)                  | 10.90 efgdef                            | 11.35 cedgcedef | 11.12defgdef | 14.23 bcbc | 11.90 bb |
| (300)                  | 12.06 cedde                            | 13.16 dcded | 16.25 bab | 18.54 aa | 15.00 aa |
| Mean                   | 10.15 cc                                 | 10.61 cc | 11.84 bb | 13.41 aa | 13.85 |

Information: Numbers in rows and columns followed by the same letter are not significantly different at the 5% and 1% levels according to the DMRT

In table 5, it can be seen that the highest soil water content was still found in 300 g hydrogel/polybag and 0 g hydrogel/polybag had the lowest water content. The application of 150 g chicken manure increased the highest water content and the lowest at 0 g chicken manure. The interaction of hydrogel and chicken manure had the highest effect on 300 g of hydrogel and 150 g of chicken manure.
Table 6. The value of soil moisture/water content due to the hydrogel and chicken manure application at 8 weeks after application

| Hydrogel (g.polybag⁻¹) | Chicken manure fertilizer (g.polybag⁻¹) | Mean |
|------------------------|-----------------------------------------|------|
|                        | (0)                                     | (50) | (100) | (150) | %       |
| (0)                    | 7.34 gf                                 | 7.62 gf | 7.66 gf | 8.32 gf | 7.7 cd  |
| (100)                  | 8.36 gf                                 | 8.92 efdef | 10.53 cdefcdef | 10.88 cdecde | 9.67 bbc |
| (200)                  | 8.85 fge                                | 10.34 defcdef | 10.38 cdefcdef | 11.46 cdecde | 10.26 bb |
| (300)                  | 10.78 cdefcdef                          | 11.64 cc | 16.27 bb | 18.57 aa | 14.31 aa |

Mean 8.83 cd 9.63 bcc 11.21 abb 12.31 aa

Information: Numbers in rows and columns followed by the same letter are not significantly different at the 5% and 1% levels according to the DMRT.

The observation of soil water content at 8 weeks after application still showed almost a similar condition as the observation at 4 weeks after incubation. The highest water content was found in the 300 g hydrogel/polybag, but 100 g and 200 g hydrogel were not significantly.

The best interaction of hydrogel and chicken manure application was in the combination of 300 g hydrogel/polybag and 150 g chicken manure/polybag. However, the soil water content at 4 weeks and 8 weeks after the application was decreased because the hydrogel began to rot at 4th to 6th weeks hence it was could not hold water optimally [11]. The amount of water stored in the soil is related to the bulk density of the soil and one of which is influenced by soil organic matter [5].

4. Conclusions
Hydrogel application significantly increased the pH, N-total and water content in Entisol soils. The application of chicken manure significantly increased the pH, N-total, C-organic, and water content in Entisol soil. The interaction of 200 g hydrogel/polybag and 150 g chicken manure/polybag produced the highest in increasing N-total and C-organic, but the interaction of 300 g hydrogel/polybag and 150 g chicken manure/polybag produced the highest in increasing pH, C-organic and soil moisture content of Entisol.

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