Field Performance of Compost Produced from Tannery waste and Sawdust Applied on Maize (Zea mays) Plants

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Abstract. A study was conducted to investigate the use of tannery waste (TW) in conjunction with sawdust (SD) as compost for agricultural purposes. The waste materials were gathered and combined in the following proportions: 1 part waste to 1 part standard deviation, 1 part waste to 5 parts standard deviation, 5 parts waste to 1 part standard deviation, 1 part waste to 10 parts standard deviation, and 10 parts waste to 1 part standard deviation. The compost obtained was used to evaluate the growth metrics (leaves, height, and stem girth) as well as the yield performances of maize plants. Maize plants that received compost (TW/SD 1:1) exhibited favourable growth patterns and successful seed development. Conversely, maize plants treated with compost (TW/SD 1:10) had the least favourable response, leading to stunted growth, reduced leaf diameters, and the narrowest stem girth. The addition of compost (with a carbon-to-nitrogen ratio of 10:1) resulted in a notable improvement in the development of maize plants, including increased height, stem thickness, and leaf length. The plants also exhibited larger leaves and a vibrant green colour. This implies that the plants were using the nutritional content of the compost (with a ratio of 10 parts wood chips to 1 part food scraps) for their development. The corn yields were collected 102 days post-planting. The average yields of maize grown with the compost TW/SD varied from 0.4±0.05kg to 1.5±0.01kg. The findings indicate that a suitable mix of tannery waste and sawdust may be used to enhance soil organic matter and increase agricultural productivity.

Keywords: Tannery waste, sawdust, composting, compost

1. Introduction

Composting is a process that involves the partial breakdown of organic matter and the conversion of it into a stable end product called compost. This process eliminates any harmful microorganisms, toxicity to plants, and enhances the humic characteristics of the compost (Elnasikh and Satti, 2017, [5]). Compost has an influence on soils, especially those that lack essential nutrients. It replenishes

IMDC-IST 2023, October 25-27, Yola, Nigeria

DOI 10.4108/eai.25-10-2023.2348752

the depleted organic components in the soil and supplies essential nutrients to plants (Olowoake et al., 2018, [21]). Microbial populations are influenced by enzyme activities, since most soil processes are aided by enzymes derived from microbes (Weerasinghe and De Silva, 2017). Additionally, it enhances crop productivity by facilitating the release of nutrients throughout the process of decomposition (Weerasinghe and De Silva, 2017, [27]).

Utilising different types of trash for compost production may be a more sustainable approach to managing solid waste (Ijah, 2006; Anwar et al., 2015, [1]). Composting is widely recognised as an eco-friendly alternative method for recycling organic solid waste (Ijah, 2006, [10]; Ezeagu et al., 2017a, [6]). Hence, composting offers a superior method for transforming tannery solid wastes into compost material that has significant agricultural value, particularly when dealing with de-hairing wastes that have a low content of heavy metals. Sawdust is a residual product of wood that consists of little particles of wood. The item in question is a carbonaceous organic material with a high carbon-to-nitrogen ratio (Betham et al., 2013, [2]). Tannery waste consists of hair waste, trims, and fleshing (Framis, 2018, [8]). Currently, there is little information available about the composting of tannery waste using sawdust as an organic additive.

Chemical fertilisers are costly and have detrimental effects on the environment. Therefore, not all farmers in underdeveloped nations have the means to acquire or get chemical fertilisers. The tanneries and wood businesses in the nation are seeing significant growth, resulting in the generation of substantial amounts of trash. Frequently, these wastes are irresponsibly discarded, leading to environmental pollution and the emission of unpleasant odours, particularly in the case of tannery waste.

Prolonged soil use, coupled with improper application of agrochemicals, has resulted in significant issues of soil nutrient depletion and widespread heavy metal pollution in Nigerian soils. Hence, it is essential to mitigate environmental issues by using cost-effective organic fertiliser derived from the bioconversion of hazardous industrial waste. Composting may effectively transform tannery waste and sawdust into a valuable agricultural resource. The majority of these wastes are organic, indicating that they may be broken down naturally. Research suggests that the preservation of organic matter in the soil is crucial for maintaining sustainable agricultural output and long-term productivity of agroecosystems (Dinesh et al., 2012, [3]). The recycling of organic wastes, such as tannery wastes, for agricultural use is crucial in areas with poor-quality soils lacking essential nutrients. This practice helps minimise reliance on chemical fertilisers, which may lead to soil health issues. Utilising compost enhances the arrangement of soil, the capacity of water to pass through it, and the fertility of the soil. Organic additives have the ability to enhance plant health and perhaps boost crop production.

The objective of the research is to evaluate the efficacy of compost derived from tannery waste and sawdust in real-world conditions. The goal is to assess the effectiveness of the compost generated in the field using maize (Zea mays) as the experimental crop.

2. Materials and Methods

Field studies: A field research was conducted in the biological garden of the Department of Biological Sciences, Federal University of Technology, Minna, Niger State, Nigeria, to assess the efficacy of the generated compost.

2.1 Overview of the experimental location: Minna is located in the central part of Nigeria and experiences a climate that corresponds to the tropical hinterland and Guinea savannah region of the country (Simmon et al., 2018, [23]). The town has a mild and dry environment, with an average daily humidity of 44.4% and an average annual rainfall of 1334 mm. The rainy season starts in April and extends until October. September has the most average monthly rainfall, reaching about 300mm. The temperature seldom falls below 22 degrees Celsius, and reaches over 40 degrees Celsius in February/March, and 35 degrees Celsius during the latter two months of November and December (Simmon et al., 2018, [23]).

2.2 Maize collection and viability testing

The maize variety used was the Open Pollinated Variety (OPV) Seed SUWAN-1-R, sourced from Premier Seed Nigeria Limited and bought from an Agro-chemical dealer outlet in Tudun Fulani, Minna, Niger State, Nigeria. The viability assessment relied on seed germination. This was accomplished by placing maize grains on a moist cloth. The towel was folded in half to retain moisture, which is one of the necessary conditions for germination. The seeds were placed in a controlled warm environment and observed daily for three days to track germination (Ezeagu et al., 2017b, [7]).

2.3 Preparation and seeding of maize on an experimental plot

The experimental plot, measuring 7.7m × 3.3m, was situated in the Biological Sciences Department Garden on the Bosso Campus of the Federal University of Technology in Minna, Niger State, Nigeria. Ridges were formed by utilising a hoe with a length of 0.4m, spaced at a distance of 0.65m between each ridge. The plot size was 0.96m × 0.41m. The maize was manually planted (in August 2019) by placing three seeds per hole at a depth of 5cm, with a spacing of 25cm between each hole, following the method given by Law-Ogbomo et al. (2012).

2.4 Seed germination and its potential for germination

After a duration of three (3) days, the seeds were examined to see whether they had started to grow. Emergence refers to the observable emergence of the shoot above the surface of the soil (Kader, 2005, [15]). Germination potential is the metric used to assess both the pace and consistency of seed germination. Liu et al. (2015) determined the germination potential.

2.5 Utilisation of compost manure and additional fertilisers

The application of compost included the process of mixing it with the soil before to planting, as described by Tanimu et al. (2013, [24]). The inorganic fertiliser, namely NPK with a composition of 20% nitrogen, 10% phosphorus, and 10% potassium, was used as a positive control in the experiment. It was administered two weeks after planting by distributing the fertiliser around the maize plants at a distance of 5cm. The application method followed the burial technique described by Olowoboko et al. (2017) [21]. Additionally, another kind of control, an exceptional organic fertiliser (commercial fertiliser), was administered to the maize plants precisely two weeks after they were planted. The fertilisers, namely NPK with a ratio of 20:10:10, and an exceptional organic fertiliser, were also administered at four weeks and eight weeks following planting, in addition to the corresponding application of compost.

2.6 Plant growth characteristics are being monitored

The number of maize plants per row was reduced from three to two plants per row one week after planting. Weeding was performed manually in all experimental plots, following the methodology outlined by Ebrahimi et al. (2019). The growth vigour rate was assessed by measuring six maize plants for each row every two weeks, and the average measurement was recorded (Olowoake et al., 2018, [22]). The measurement of plant height included determining the distance from the base of the plant to the height of the first tassel branch. Similarly, ear height was assessed by determining the distance to the node that bears the top ear (Hammed, 2015, [9]). The researchers Usman et al. (2013) used the direct observation technique (DOM) with a metre rule to accomplish this, as stated in their study [26]. The length of the leaf was measured manually, rounded to the closest centimetre, from the tip of the leaf to the point where the lamina was connected to the petiole, using the method given by Ezeagu et al. (2017b) [7]. The agronomic data collected included measurements of plant height, leaf length, and stem girth, which were recorded in centimetres using a metric rule. Additionally, the crop yield was determined by weighing the harvested produce using a scale, with the measurements recorded in kilogrammes.

2.7 Quantitative analysis of data using statistical methods

The data acquired from the field research were analysed using one-way analysis of variance (ANOVA). To evaluate the difference between the mean values of the treatments at a significance level of 5%, Duncan's test was used. The analysis was conducted using SPSS software (Version 21, IBM SPSS). Statistical significance was determined at a threshold of $P < 0.05$.

3. Results

3.1 The germination index (emergence percentage) of maize

Table 1 shows the germination index (% emergence) of maize planted in soil amended with compost. The mean emergence ranged from 27.39±4.61 to 60.75±4.5%, 60.75±4.5% - 100±0.0%, and 94.59±2.89 – 100±0.0% for day 4, 5 and 6 respectively. Four days after cultivation of the maize seeds, TW/SD 5:1 and TW/SD 10:1 recorded 44.34±4.1% emergence, while TW/SD 1:1 recorded 27.78% emergence. At the fifth (5) day of cultivation, TW/SD 1:1 had 60.75±4.5% emergence, while the TW/SD 1:10 recorded 100±0.0% emergence. After 6 days of cultivation of the maize seeds only TW/SD 5:1 recorded 94.46±2.11% emergence as compared to 100±0.0% in all other treatments including unfertilized soil (Table 1).

Table 1: Germination index (%) (emergence) of maize planted in soil amended with compost

Treatments	**Day five (5)**	**Day four (4)**	**Day six (6)**
TW/SD 1:1	27.39±4.61 a	60.75±4.5 a	100±0.0 b
TW/SD 1:5	33.26±2.9 b	88.89±0.0 e	100±0.0 b
TW/SD 5:1	44.34±4.1 d	72.22±2.0 b	94.4±2.11 a
TW/SD 1:10	33.47±1.15 b	100±0.0 g	100±0.0 b
TW/SD 10:1	44.36±2.11 d	94.59±2.89 e	100±0.0 b
No manure	27.39±3.14 a	81.84±2.26 d	100±0.0 b
Amazing organic fertilizer (Commercial)	38.51±3.62 c	94.4±3.05 f	100±0.0 b
NPK fertilizer (20:10:10)	61.11±1.11 e	77.57±2.57 c	100±0.0 b

TW: Tannery waste, SD: Sawdust

Mean values represented by different letters along same column are significantly different from each other at $P<0.05$

3.2 The effect of compost produced on the plant height

The effect of compost on maize plant heights is presented in Figure 1. Two (2) weeks after planting (WAP), plant heights were almost the same; the mean values ranged from 13.5±0.8 to 15.0±0.2 cm. The lowest mean value (13.5 ±0.8cm) was observed in maize plants raised with TW/SD 5:1, while the highest mean value (15.0±0.2cm) was recorded at TW/SD 10:1. At 4 WAP the heights ranged from 44.3±2.8 to 86.0±4.1cm, with the highest mean value (86.0±4.1cm) recorded at TW/SD 10:1. The lowest mean height (44.3±2.8cm) was at TW/SD (1:10). Six (6) and eight (8) weeks after planting, the maize plants from TW/SD (10:1) were of significant height with mean values of 123.6±6.5cm and 154±6.19cm respectively. Maize heights (100.0±7.8cm, 119.8±19.4cm and 121.5±9.2 cm) recorded at TW/SD 1:1 at 6, 8 and 10 WAP, had remarkable growth compared to control and TW/SD 1:10. At 8 and 10 WAP lowest plant heights (66.5±6.5cm and 69.5±6.5cm respectively), were recorded at TW/SD 1:10, while the highest value (154.0±6.19cm and 155.8±5.6cm) were recorded at TW/SD 10:1 (Figure 1). At 8 WAP treated maize plants at TW/SD (1:1) were the first to produce tassels among the treatments.

3.3 Effects of compost on leaf length

The effects of the compost (TW/SD 1:1, 1:5, 5:1, 1:10 and 10:1 respectively) on leaf length are presented in Figure 2. At 2 WAP the leaves were almost of equal length (5.8±0.1 - 6.5±0.1cm). The highest mean value for leaf length of 6.5±0.1cm was recorded at TW/SD 10:1, while the least value (5.8±0.1cm) was observed in plants raised with TW/SD 1:1. At 4 and 6 WAP the leaf length ranged from 37.0±1.9cm to 61.6±2.3cm and 51.3±4.0cm to 81.5±3.8cm respectively with the highest leaf length (61.6±2.3cm and 81.5±3.8cm) observed at TW/SD 10:1, while the least mean leaf length, 37.0±1.9cm and 51.3±4.0cm respectively were recorded at TW/SD 1:10. At 8 and 10 WAP mean leaf length was (83.5±3.1cm and 83.5±3.10cm) higher at TW/SD 10:1, than other treatments while the least values (53.8±3.5cm and 54.8±3.2cm) were observed at TW/SD 1:10 respectively.

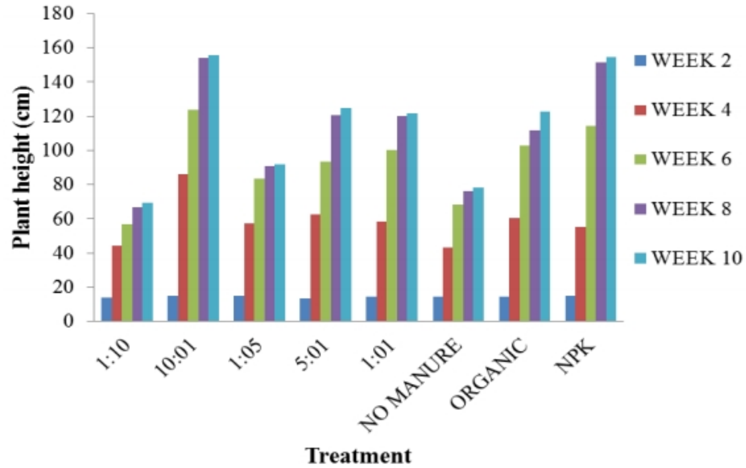

Figure 1: Effects of compost on plant height

3.4 The effect of compost on stem girth

The stem girths of the maize plants were recorded in centimetres (cm) across the treatments. At 2 weeks after planting (WAP) the stem girth was between 1.1 ± 0 cm and 1.2 ± 0cm for all treatments. At 4 and 6 WAP the stem girth ranged from 2.2.±0.1cm to 4.0±0cm and 2.8±0.2cm to 4.8±0cm respectively, with the highest stem girth, 4.0±0cm and 4.8±0cm recorded at TW/SD (10:1). The lowest stem girth were 2.2 .± 0.1cm and 2.8±0.2cm observed at TW/SD (1:10) respectively. At 8 and 10 WAP the stem girth of maize plants raised with TW/SD (1:10) had the least values of 2.9±0.2cm and 3.0±0.2cm respectively, while higher stem girth of 4.8±0.1cm and 4.9±0.13cm were observed at TW/SD (10:1). The least mean value 3.0 ± 0.2cm was observed at TW/SD (1:10) treated maize plants (Figure 3).

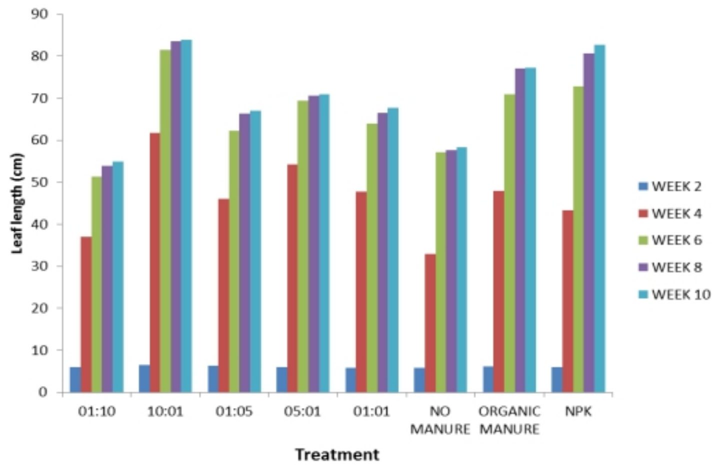

Figure 2: Effect of compost on leaf length

3.5 Effect of compost produced on maize yield

Maize plants raised with the compost TW/SD (1:1, 1:5, 5:1, 1:10 and 10:1 respectively) had yields. The yields from the compost TW/SD 1:1 was 1.5±0.01kg, followed by TW/SD 1:5 with 1.4±0.05kg, while TW/SD (10:1) recorded 1.3±0.01kg. Maize plants raised with TW/SD 1:5 had a yield of 0.7±0.0kg, and the least was observed in TW/SD 1:10 with 0.4±0.05kg (Table 2).

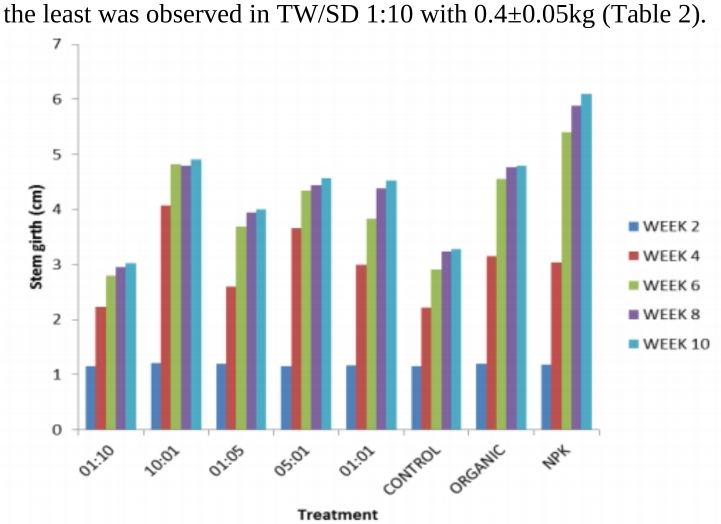

Figure 3: Effects of compost on stem girth

Table 2. Yields of maize planted in soil amended with compost produced

Treatments	Yields of maize (Kg)
TW/SD 1:1	1.5 ± 0.1^{bc}
TW/SD 1:5	0.7 ± 0.0^{a}
TW/SD 5:1	1.4 ± 0.05^{bc}
TW/SD 1:10	0.4 ± 0.05^{a}
TW/SD 10:1	1.3 ± 0.1^{b}
No manure	0.5 ± 0.03^{a}
Amazing organic fertilizer (Commercial)	1.2 ± 0.0^{b}
NPK fertilizer (20:10:10)	1.8 ± 0.3^{c}

Means values represented by different letters along same column are significantly different from each other at $P<0.05$

4. Discussion

The resultant compost (TW/SD) produced were applied as a treatment to maize plants. The ability of the maize seeds to germinate in all treatments showed that the compost TW/SD (1:1, 1:5, 5:1, 1:10 and 10:1 respectively) had no phytotoxic effects on the maize plants. Jeyapandiyan et al. (2017), [12] and Tibu et al. (2019), [25] have reported that compost displaying more than 80% germination index is free from phytotoxic compounds and maturity is satisfactory. Compost maturity depends on many factors such as characteristics of primary waste materials (C:N ratio, moisture, organic matter, pH and porosity) as well as process situations. Lim et al. (2013), [18] reported that the use of mature compost is of great significance because the direct use of organic matter in the soil may generate toxins and threaten the environment. It was very difficult to ascertain which compost matured before others, however, based on temperature readings and C:N ratio, TW/SD 1:1 matured before TW/SD 5:1 and TW/SD 10:1, while TW/SD 1:5 and TW/SD 1:10 took a longer time to mature probably due to slow rate of decomposition. The slow rate of decomposition could be due to the high ratio of sawdust to tannery waste in the composting mixture. Lennox et al. (2019), [17] reported that microbial degradation of sawdust was very difficult due to the presence of lignin, a highly recalcitrant constituent.

Compost (TW/SD 10:1) supported a good growth pattern. Two weeks after planting the plants' height were almost the same in the different treatments (Figure 1). At four, six and eight weeks after planting, the maize plants had shown a significant increase in height, stem girth and leaf length. During the growing period it was observed that, with this compost mix (TW/SD 10:1), the leaves were greenish with extensive leaf sizes. This suggests that the nutrient content of the compost (TW/SD 10:1) was being utilized by the plants for their growth. Organic manure has a specific characteristic nature of slow release of nutrients (Makinde and Ayoola, 2010). For vegetable plants such as African spinach, fluted pumpkin (ugu), sorrels, cabbage, salads etc., this particular ratio might be recommended, since the leaves are of the interest most. Olowoake et al. (2018), [21] acknowledged that compost enriched crop yield by improving nutrient status and microbial action in the soil.

Maize plants treated with compost (TW/SD 1:1), supported good growth patterns as well as seed formation. This result is in agreement with Weerasinghe and De Silva (2017), [27] who reported the use of compost made from municipal solid waste (MSW) to grow Zea mays (maize), and found that the best soil compost ratios that significantly improved the growth parameters of maize was 1:1 followed by 1:0.5. In addition, it was in this treatment (TW/SD 1:1), that tassels were produced eight weeks (56 days) after planting which resulted in the production of good seeds as well as yield. Khan (2015), [14] reported that compost use heightens days to tasselling. This suggests that when this compost (TW/SD 1:1) is applied to cereals and legumes good harvest could be obtained since the seeds are of interest.

Maize plants treated with compost (TW/SD 1:10) had the poorest response on the plants, resulting in stunted growth with smaller leaf sizes as well as the narrowest stem girth. The plants were the last to produce tassels which led to the poorest cob formation/seeds and to some extent without seeds formed. This might be attributed to the ratio of sawdust being higher than the tannery waste used, coupled with the slow decomposition of sawdust, as a longer period might have been required for complete disintegration and mineralisation. Lennox et al. (2019) reported that sawdust takes an average of 180 days to disintegrate or be incorporated into the soil due to lack of nitrogen. Moreover, sawdust has less nitrogen when compared with another bulking agents such as straw, rice bran and leaves (Anwar et al., 2015, [1]).

Maize plants treated with NPK fertilizer caused a significant increase in plant height with the tallest plant reaching 203cm, in leaf length as well as stem girth. This might have been so because the NPK fertilizer that was applied released its nutrients rapidly as against compost (TW/SD), which releases nutrients gradually and takes a longer time for mineralization to occur. Makinde and Ayoola (2010) reported that inorganic fertilizers are branded to have the uniqueness of fast discharge of their nutrient contents. Olowoboko et al. (2017), [21] reported that the maize plant requires a sufficient supply of nutrients particularly the macro-elements (NPK) for optimal growth and yield. Controlled plot (No manure) had lower values for the plant qualities, probably due to a lack of essential nutrients.

Maize yields were obtained 102 days after planting (i.e., 14 weeks and four days). The results of this study are within the range reported by Usman et al. (2013), [26] who studied the weekly performances of maize plants through the harvesting period of (106 days after planting) under sandy soil managed with different organic materials treatment. The mean yields of maize plants raised from the compost TW/SD 1:1 was 1.5±0.01kg, followed by TW/SD 1:5 with 1.4±0.05kg, while TW/SD (10:1) recorded 1.3±0.01kg. Maize plants raised with TW/SD 1:5 had a yield of 0.7±0.0kg, and the least was observed in TW/SD 1:10 with 0.4±0.05kg. The difference in yield might be attributed to the rate at which macro and micronutrients of the compost utilization by the maize plant during growth.

The results of this finding showed the better performance yield output under plot treated with compost TW/SD 1:1, followed by TW/SD 5:1, and then TW/SD 10:1. However, maize treated with compost TW/SD 1:10 yielded the poorest number of maize cob and weight of fresh maize when compared with no manure (control) plot. In this study, it has been shown that yields have differed between the compost ratios as well as the controls (with or without fertilizer). Thus, it showed that there were significant differences ($P<0.05$) among the treatments.

5. Conclusions

The observed field performance for the treatments showed that compost manure can be used to grow maize plants successfully. TW/SD (1:1) compost was more effective than all other composts, followed by TW/SD (10:1) when plant parameters such as height, leaf length, stem girth and yields were considered. The compost TW/SD (1:10) showed negative effects on plant parameters. Maize yields were obtained 102 days after planting (i.e., 14 weeks and four days).

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