Application of liquid organic and inorganic fertilizer on growth and production of hybrid maize

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Abstract. Organic fertilizers can be an alternative source of plant nutrients. The aim of experiment is to determine the effect of liquid organic and inorganic fertilizer application on hybrid maize growth and yield. The experiment was conducted at Soppeng regency, South Sulawesi from September to December 2019. The experiment was set in Randomized Block Design with eight level of treatments and three replications. Treatments were (P1) control, (P2) inorganic fertilizer 100% recommendation, (P3) inorganic fertilizer 75% recommendation; (P4) liquid organic fertilizer 5 ml 2 L⁻¹ water + P3; (P5) liquid organic fertilizer 10 ml 2 L⁻¹ water + P3; (P6) liquid organic fertilizer 15 ml 2 L⁻¹ water + P3; (P7) liquid organic fertilizer 20 ml 2 L⁻¹ water + P3; and (P8) liquid organic fertilizer 10 ml 2 L⁻¹ water + P2. Combinations of liquid organic plus inorganic fertilizer produce better growth and higher production than only inorganic fertilization and control. The combination of liquid organic and inorganic fertilizer 75% recommendation (15 ml 2 L⁻¹ water + NPK Phonska 300 kg ha⁻¹ + Urea 150 kg ha⁻¹) show better agronomic performance and yield components with grain yield 8.2 t ha⁻¹ higher than other treatments. This dosage could be used for optimum maize production.

1. Introduction
Corn is a food crop commodity that has a strategic role in Indonesia, including as a source of second carbohydrates after rice, the snack industry and in several countries have begun to be used as an alternative fuel (bioenergy) so that the need for corn is increasing along with the increasing population growth and the development of livestock and industrial businesses that use corn as raw material. According to Swastika et al. [1] for 2020, It is predicted that the need for feed based on the approach of the livestock population is 13.36 Mt and the projection of feed production from the factory will reach 18.64 Mt.

There are still many opportunities to increase domestic maize production. Efforts that can be made include increasing plant productivity through proper and efficient plant nutrient management through fertilization. The use of inorganic fertilizers takes a top priority with a relatively high amount and continuously, this has a negative impact on the soil environment and causes the imbalanced on soil biological ecosystem and lead to land degradation [2,3]. An alternative source of nutrients for plants is the use of organic fertilizers. Organic fertilizers can improve the physical, chemical and biological properties of the soil and also help reduce the use of inorganict fertilizer so that it is more environmentally friendly.

Liquid organic fertilizer contains various macro and micro nutrients and the amino acids that is needed by plants. In addition, liquid organic fertilizers contains microorganisms that will improve soil fertility so that it can support plant growth and development. Microbes are added to organic fertilizers in...
addition to increasing nutrient availability, also able to increase the efficiency of uptake of nutrients by plants so that fertilization efficiency increases [6]. The application of liquid organic fertilizer is thought to accelerate the synthesis of amino acids and proteins, thereby accelerating plant growth. This is in accordance with the opinion of [4] that liquid organic fertilizers contain potassium which plays an important role in every plant metabolic process, namely in the synthesis of amino acids and proteins from ammonium ions. The element potassium also plays a role in maintaining good turgor pressure so as to allow the smooth running of metabolic processes and ensure the continuous elongation of cells. According to [5] liquid organic fertilizers are fertilizers with a low chemical content of a maximum of 5%, can provide nutrients in accordance with the needs of plants in the soil, because of its liquid form. Liquid organic fertilizers in fertilization are clearly more evenly distributed and there will be no accumulation of fertilizer concentrations in one place, this is because liquid organic fertilizer is 100% soluble. Liquid organic fertilizers have the advantage of being able to increase nutrient uptake and quickly overcome nutrient deficiencies because the nutrients in it have broke down so that they are more easily to absorb.

A number of studies have shown that the use of organic fertilizers in either solid or liquid form can also provide good plant growth and yield. Research results by Pangaribuan et al. [6] showed that a combination of liquid organic fertilizers and inorganic fertilizers (Urea, SP-36, and KCl) of 20% recommendation can be an alternative fertilizer for sweet corn that is more economical because its growth and production are the same as recommended inorganic fertilizers. Research by Puspadewi et al. [7] showed that it is based on considerations from an ecological and economic perspective, the combination of 1 times the concentration of liquid organic fertilizer with ½ dose of N, P, K fertilizer is able to provide a better effect on the growth and yield of sweet corn plants, and has a productivity equivalent to the treatment of 1 dose of fertilizer N, P, K, which is 17.46 t ha⁻¹. Hidayat et al. [8] reported that providing liquid organic fertilizer can reduce the use of inorganic fertilizers by 25% for growth and yield variables of maize. Using liquid organic fertilizer in sweet corn showed a noticeable effect on the number of leaves, ear length, ear diameter, ear weight per plant and ear weight per plot [9].

The purpose of this paper is to study the effect of liquid organic and inorganic fertilizers on the growth and yield of hybrid maize. The use of liquid organic fertilizers is expected to reduce the use of inorganic fertilizers in order to achieve environmentally friendly and sustainable agriculture.

2. Materials and methods
This experiment was carried out on farmers’ land in Pajalesang Village, Lilirilau District, Soppeng Regency, South Sulawesi in September to December 2019. The experimental land is classified as Alluvial soil type.

This experiments used hybrid mayze HJ 21 variety, pesticides, inorganic fertilizers (NPK Phonska and Urea) and Liquid Organic Fertilizers (LOF). The Liquid organic fertilizers had nutrients composition: N: 3.93%, P₂O₅: 3.92%, K₂O: 3.61%, micro nutrients (Fe, Mn, Cu, Zn, C0, Pb, Cd, As, Hg , B, Mo, Ce, Ca), pH 7.25 and C- organic 14.28%.

This experiment was set in a randomized block design (RBD) with eight treatments and three replications. These treatments are as follows:

P1 = Control
P2 = Inorganic fertilizer 100% recommendation
P3 = Inorganic fertilizer 75% recommendation
P4 = Liquid organic fertilizer 5 ml 2 L⁻¹ water + P3
P5 = Liquid organic fertilizer 10 ml 2 L⁻¹ water + P3
P6 = Liquid organic fertilizer 15 ml 2 L⁻¹ water + P3
P7 = Liquid organic fertilizer 20 ml 2 L⁻¹ water + P3
P8 = Liquid organic fertilizer 10 ml 2 L⁻¹ water + P2
The data were analyzed by analysis of variance (ANOVA) and with DMRT at 5%. Maximum tillage using a tractor. The treatment plots were made of 8 plots for each replication so that there were 24 plots with a plot size of 6 m x 4 m (14 m²). The distance between treatment and replicates was 50 cm and 75 cm.

To prevent downy mildew, maize seeds are soaked in a solution of 5 g of Rhizomil in 7.5 ml of water for every kg of seeds. Planting seeds using a spacing of 75 x 20 cm with one seed per hole at a depth of 3 cm, then the hole is closed with soil. Plant maintenance includes controlling weeds, pests and diseases. Liquid organic fertilizer was applied by spraying it on under of the maize leaves. Liquid organic fertilizer was applied at 15, 30 and 45 days after planting (DAP). Spraying is carried out at 06.00 to 09.00 am or 16.00 to 18.00 pm. Inorganic fertilizers (NPK Phonska and Urea) were given at the age of 7 and 30 days after planting. Fertilizer is applied by immersing about 3 cm from the maize plant. Dose of fertilizer according to treatment. During the research, it was relatively free from pests and diseases. Harvesting is done when the ear husks have dried or turned brown, the seeds have hardened, and at least 50% black coating has been formed on each row, the age of the plant is 82 days after planting.

The variables observed in this experiment were (1) plant height (cm), (2) number of leaves, (3) ear height (4) stalk diameter, (5) leaf area, (6) ear length, (7) ear diameter (8) number of rows per ear, (9) number grain per rows, (10) yield levels (11) grain moisture content at harvest, (12) weight of 1,000 grain (13) wet ear weight (kg) and (14) grain yield (t ha⁻¹).

3. Results and discussion
Based on the chemical analysis of the soil, it can be seen that the experimental site has a topsoil texture (0-20 cm) is silt loam Soil pH was 7.13. Levels of C-organic are low, N-total and C N⁻¹ are classified as low. P-potential (HCl 25%) and P-Bray-1 is very high (>60). The K-potential (HCl 25%) was moderate and the K-dd level was high. The levels of Ca and Mg cations are classified as very high and high. The cation exchange capacity (CEC) is high and base saturation (BS) is high.

Variance analysis showed that the treatment had a significant effect on the variables of plant height, stem diameter and leaf area, while ear height had no significant effect ( Table 2). The effect of the combination of liquid organic fertilizers and inorganic fertilizers on plant height variables showed that the treatment of liquid organic fertilizer at doses of 10, 15, 20 (ml per 2 L water) with 75% and 100% of the recommended NPK dosage (P5, P6, P7, P8) had an effect better than only inorganic fertilizer (P2,P3) and control (P1) ( Table 2). This shows that the addition of 10 to 20 ml per 2 L of liquid organic fertilizer is quite effective for the growth of maize plant height. Liquid organic fertilizer 15 ml per 2 L of water and 75% NPK recommendation showed the highest plant height at 60 DAP of 199.7 cm. The increase in plant height due to the application of liquid fertilizer to corn plants is in accordance with the results of research by Pangaribuan et al. [6]; Puspadewi et al. [7] and research by Pasaribu et al [12].

The combination of liquid organic fertilizer and inorganic fertilizer with a dose of 15 ml per 2 L of water + 75% NPK (P6) on the number of leaves showed a better effect than other combinations and was significantly different from the control (P1), only inorganic fertilization (P2, P3) and combination treatment (P5). This shows that the nutrient content in the combination of doses can encourage the increase in the number of leaves more than other doses. Leaves are the main organ where photosynthesis takes place. optimal leaves allows light to be more evenly distributed between leaves. Leaves with a higher amount allows more fertilizers to stick to the leaves, as well as optimal nutrient absorption. The research result by Pangaribuan et al.[6] showed that all treatments combined with liquid and inorganic organic fertilizers gave more leaves than the control.
Table 1. Result of soil chemical analysis before experiment (Soil Laboratory, Assessment Institute for Agricultural Technology South Sulawesi, 2019).

| No | Parameter | Score | Criteria² |
|----|-----------|-------|-----------|
| 1  | Texture (%) |       |           |
|    | - Sand     | 37    | Silt loam |
|    | - Silt     | 60    |           |
|    | - Clay     | 3     |           |
| 2  | pH         |       |           |
|    | - H₂O      | 7.13  | Neutral   |
|    | - KCl      | 6.05  |           |
| 3  | Organic matter (%) | 1.85 | Low |
|    | - C-organic |       |           |
|    | - N-Total  | 0.18  | Low       |
|    | - C N⁻¹    | 10    |           |
| 4  | Extract HCl 25 % (mg 100 gr⁻¹) |       |           |
|    | - P₂O₅     | 68    | Very high |
|    | - K₂O      | 40    | moderate  |
| 5  | Olsen per Bray (ppm) |       |           |
|    | - P₂O₅     | 100   | Very high |
|    | - K₂O      | 29    | High      |
| 6  | Exchange Cations (me 100 gr⁻¹) |       |           |
|    | - Ca       | 22.16 | Very high |
|    | - Mg       | 7.20  | High      |
|    | - K        | 0.06  | Very low  |
|    | - Na       | 0.55  | Moderate  |
|    | Total      | 29.97 |           |
| 7  | KTK CEC    | 39.92 | High      |
| 8  | Base Saturation (%) | 75   | High      |

Source: * Indonesian Soil Research Institute [11]

Fertilization application did not significantly affect ear height (Table 2). However, the combination of organic and inorganic fertilizers tended to show better ear height than control (P1) and inorganic fertilizers (P2, P3). Stem diameter and leaf area are important growth characteristics to support maximum production. Application of a combination of liquid organic and inorganic fertilizers (P4, P5, P6, P7) on stem diameter and leaf area showed a better effect and significantly different from control (P1). The highest stem diameter and leaf area were 25.8 cm and 770.0 cm combined with 15 ml per 2 L of liquid organic fertilizer + 300 kg NPK + Urea 150 kg ha⁻¹ (P6). The diameter of the stem is the storage organ for assimilates before being mobilized to the seeds while the leaf area is important for the active photosynthesis process. The research results by Purwanti et al. [13] showed that the treatment of biological fertilizers + fertilizers N, P, K produced wider leaves when compared to the provision of 2 times biological fertilizers alone. The higher the leaf area, the higher the photosynthesis process, so that more photosynthetic results are produced [14]. According to Araus et al. [15] plants must have the ability to maintain a photosynthetic active leaf area so as to maintain the rate of assimilate formation for seed formation and development. Maintang et al. [16] found a significant positive correlation between stem diameter and leaf area on the yield of corn kernels. This is in line with Earl and Davis [17] that in the absence of stress, leaf area has a positive effect on seed yield.


Table 2. Plant height and number of maize leaves at various levels of liquid organic fertilizers and inorganic fertilizers.

| Treatment | Plant height (mm) | Number of leaves | Ear Height (mm) | Stalk diameter (mm) | Leaf area (mm) |
|-----------|-------------------|------------------|-----------------|---------------------|----------------|
| P1        | 160.6 b           | 13.0 b           | 87.7            | 21.5 b              | 599.1 b        |
| P2        | 177.9 ab          | 13.6 b           | 90.9            | 23.8 ab             | 788.3 a        |
| P3        | 179.5 ab          | 13.4 b           | 90.4            | 23.4 ab             | 716.5 a        |
| P4        | 177.0 ab          | 14.0 ab          | 105.3           | 25.4 a              | 723.0 a        |
| P5        | 186.4 a           | 13.4 b           | 97.7            | 25.0 a              | 767.5 a        |
| P6        | 199.7 a           | 14.8 a           | 113.5           | 25.8 a              | 770.0 a        |
| P7        | 187.1 a           | 13.9 ab          | 106.8           | 24.3 a              | 703.5 a        |
| P8        | 187.9 a           | 13.9 ab          | 97.5            | 23.6 ab             | 733.8 a        |
| % CV      | 7.07              | 3.78             | 11.62           | 5.51                | 8.06           |

Information: P1 = Control; P2 = Inorganic fertilizer 100% recommendation; P3 = Inorganic fertilizer 75% recommendation; P4 = Liquid organic fertilizer 5 ml 2 L\(^{-1}\) water + P3; P5 = Liquid organic fertilizer 10 ml 2 L\(^{-1}\) water + P3; P6 = Liquid organic fertilizer 15 ml 2 L\(^{-1}\) water + P3; P7 = Liquid organic fertilizer 20 ml 2 L\(^{-1}\) water + P3; P8 = Liquid organic fertilizer 10 ml 2 L\(^{-1}\) water + P2

Table 3. Cob length, cob diameter, number of row cob, the number of seeds row, weight 1,000 seeds at various levels of liquid organic fertilizers and inorganic fertilizers.

| Treatment | Ear length (cm) | Ear diameter (mm) | Number of rows per Ear | Number of grains per row | Weight 1,000 grain (gr) |
|-----------|-----------------|-------------------|------------------------|--------------------------|------------------------|
| P1        | 13.9 b          | 43.6 d            | 13.3                   | 24.4 b                   | 323.3 b                |
| P2        | 16.7 a          | 45.7 c            | 13.9                   | 30.2 a                   | 413.3 a                |
| P3        | 17.5 a          | 46.0 c            | 13.6                   | 32.2 a                   | 432.3 a                |
| P4        | 18.1 a          | 48.2 a            | 13.8                   | 32.8 a                   | 436.6 a                |
| P5        | 17.3 a          | 45.35 c           | 14.3                   | 30.3 a                   | 436.7 a                |
| P6        | 18.6 a          | 48.8 a            | 13.4                   | 33.5 a                   | 423.3 a                |
| P7        | 16.3 a          | 46.52 bc          | 13.9                   | 31.8 a                   | 410.0 a                |
| P8        | 16.6 a          | 47.9 ab           | 13.9                   | 31.0 a                   | 423.3 a                |
| % CV      | 7.84            | 1.78              | 4.29                   | 8.38                     | 5.27                   |

Information: P1 = Control; P2 = Inorganic fertilizer 100% recommendation; P3 = Inorganic fertilizer 75% recommendation; P4 = Liquid organic fertilizer 5 ml 2 L\(^{-1}\) water + P3; P5 = Liquid organic fertilizer 10 ml 2 L\(^{-1}\) water + P3; P6 = Liquid organic fertilizer 15 ml 2 L\(^{-1}\) water + P3; P7 = Liquid organic fertilizer 20 ml 2 L\(^{-1}\) water + P3; P8 = Liquid organic fertilizer 10 ml 2 L\(^{-1}\) water + P2

Analysis of variance showed that the treatment had a significant effect on the variables of ear length, ear diameter, number of seeds per row, weight of 1,000 seeds (Table 3), wet ear weight and grain yield (t ha\(^{-1}\)) (Table 4), while the number of rows per ear (Table 3), grain moisture content and yield levels of maize (Table 4) had no significant effect.

Liquid organic fertilizer treatment, inorganic fertilizers and their combination produce plants with length and diameter ear, number of row per ear, number of seeds per row, weight 1,000 grain, higher than the control (without fertilizer) (Table 3). As well as, the variables of grain moisture content, yiled levels, wetear weight and grain yield, higher than the control (Table 4). Treatment of liquid organic fertilizer (15 ml 2 L\(^{-1}\) water) + 75% recommendation for inorganic fertilizers (P6), tend to give the best growth in some of these yield components, although statistically not different from inorganic fertilizer treatment (P2-P3) and combination treatment (P4-P8). Yield components such as ear length, ear...
diameter, wet ear weight and yield levels determine the yield obtained. This is because diameter affects number of seed rows on the cob, cob length affects the number of seeds per row whereas high seed yield indicates that the partition of assimilates to seeds is greater than that of other organ parts such as cloves.

Table 4. Water content, rendement, weight of wet peeled cob and yield at various levels of liquid organic fertilizers and inorganic fertilizers.

| Treatment | Grain moisture content | Yield | Wet ear weight (kg per field) | Grain yield (t ha⁻¹) |
|-----------|------------------------|-------|-------------------------------|---------------------|
| P1        | 33.4                   | 0.65  | 5.46 c                        | 4.6 c               |
| P2        | 32.5                   | 0.67  | 8.49 ab                       | 7.62 ab             |
| P3        | 33.6                   | 0.68  | 7.90 ab                       | 7.0 ab              |
| P4        | 31.6                   | 0.69  | 8.50 ab                       | 7.93 ab             |
| P5        | 36.0                   | 0.65  | 8.62 a                        | 7.12 ab             |
| P6        | 32.5                   | 0.69  | 8.82 a                        | 8.22 a              |
| P7        | 33.7                   | 0.69  | 7.36 b                        | 6.6 b               |
| P8        | 35.8                   | 0.68  | 8.26 ab                       | 7.16 ab             |
| % CV      | 10.7                   | 4.63  | 8.18                          | 10.05               |

Information: P1 = Control; P2 = Inorganic fertilizer 100% recommendation; P3 = Inorganic fertilizer 75% recommendation; P4 = Liquid organic fertilizer 5 ml 2 L⁻¹ water + P3; P5 = Liquid organic fertilizer 10 ml 2 L⁻¹ water + P3; P6 = Liquid organic fertilizer 15 ml 2 L⁻¹ water + P3; P7 = Liquid organic fertilizer 20 ml 2 L⁻¹ water + P3; P8 = Liquid organic fertilizer 10 ml 2 L⁻¹ water + P2

The combination of 75% recommended inorganic fertilizer and liquid organic fertilizer at a dose of 5 to 15 ml 2 L⁻¹ of water (P4-P6) gives higher grain yields, not significantly different from the recommended dosage of inorganic fertilizer treatment (P2-P3). The highest seed production was indicated by P6 treatment with a grain yield of 8.2 t ha⁻¹. This shows that the use of liquid organic fertilizer with a dosage range of 5 to 15 ml 2 L⁻¹ of water + 75% inorganic fertilizer recommendation is quite effective for the growth and yield of maize. The treatment of liquid organic fertilizers + 75% inorganic fertilizers can reduce the use of inorganic fertilizers (Urea, NPK) by up to 25%. Research result by Pangaribuan et al. [18] showed that reduction in the use of inorganic fertilizers (Urea, SP-36 and KCL) by up to 80% with the use of liquid organic fertilizers on sweet corn plants. The application of organic fertilizers combined with inorganic fertilizers is expected to create well-maintained soil conditions, increase plant productivity and be efficient in the use of fertilizers so that it can suppress or minimize the use of inorganic fertilizers.

Application of combination liquid organic fertilizer and inorganic fertilizer on maize plants in this study had a significant effect on plant height, stem diameter, leaf area, ear length, ear diameter, number of grains per row, weight of 1,000 grain, wet ear weight and grain yield (t ha⁻¹). This shows that liquid organic fertilizers can be used as a source of nutrients to support plant growth and production. As previously explained, liquid organic fertilizers contain macro and micro nutrients. The results of this study are in line with research result by Syofia et al. [23] showed that the liquid organic fertilizer "Santamicro" with a concentration of 3 ml L⁻¹ of water applied by spraying gave the best results on yield and yield components of sweet corn varieties Jambore and Bonanza. Puspadewi et al. [7] reported that the concentration of liquid organic fertilizers with fertilizer doses of N, P, K affected plant height, stem diameter, leaf area, ear length, ear diameter, ear weight, crop yield, harvest index and total dissolved solids of sweet corn varieties Talenta. Application of organic matter and application of inorganic fertilizers can increase soil pH, total N, available P and K-available in the soil, nutrient levels and uptake of N, P and K plants, and increase corn production [24, 25]. Research result by Rahman et al. [26] showed that the addition of 20 t of organic matter per ha accompanied by NPK fertilizer with a dose of Urea 200 kg ha⁻¹, SP-36 200 kg ha⁻¹ and KCL 100 kg ha⁻¹ obtained the highest maize production, namely 7.83 t ha⁻¹.
1. Fertilizing corn with a combination of inorganic and organic fertilizers increases the production of maize crops both ear length, ear circumference and dry shell weight (27,28). Zhang et al.[29] reported that inoculation of AM fungi in field soil with optimal organic fertilizer application greatly improved maize growth and nutrient uptake. Research on other plants has also shown that application of liquid fertilizers and a combination of liquid organic fertilizers and inorganic fertilizers had a significant effect on plant growth and yield including cabbage [19]; bean [20]; Shallot [21]; carrot [5]; lowland rice [9, 22].

Liquid organic fertilizers have several benefits, including being able to encourage and increase the formation of leaf chlorophyll and the formation of root nodules in legume plants, thereby increasing the ability of plant photosynthesis and absorption of nitrogen from the air, can increase plant vigor so that plants become sturdy and strong, increase plant resistance to drought, weather stress and attack by disease-causing pathogens, stimulate the growth of production branches, and increase the formation of flowers and ovaries, and reduce the loss of leaves, flowers and ovaries [20]. The application of liquid organic fertilizer by spraying on the underside of the corn leaves makes it easier for plants to absorb the nutrients contained in the fertilizer. Other than that, according to Panngaribuan et al. [6] the content of auxin and gibberellin hormones in liquid organic fertilizer has a positive effect on the ability of plants to absorb and make these nutrients effective.

According to the description, the liquid organic fertilizer used in this study is 100% organic material and can be directly used as foliar fertilization for food crops, plantations and horticulture. Foliar fertilization provides crops with equally distributed and easily absorbable during plant development [30]. Organic fertilizers contain low macro nutrients but contains enough micro nutrients, which are necessary for plant growth. Micro nutrient elements contained in liquid organic fertilizers play a role in increasing plant metabolism. Husnain et al. [3] reported that for the effectiveness and efficiency of fertilization, the management of macro nutrients N, P, and K must be accompanied by the management of micro nutrients and beneficial nutrients. Provision of micro and beneficial fertilizers as well as ameliorant applications including organic matter and other ameliorants on suboptimal land such as on acid dry land, new openings of rice fields, also rainfed land needs attention. The use of liquid organic fertilizers can be an option because currently, many foliar fertilizers are added with growth hormones, natural plant enzymes, microorganisms and other materials that have added value to improve soil fertility. Foliar fertilizer is commonly used as a supplement to soil fertilization in order to improve the crop yield and quality (31). Based on the benefits and advantages of liquid organic fertilizers, the results of this study can be used as additional information to expand the use of organic fertilizers, especially liquid organic fertilizers, as a nutrient source at the farm level so as to support sustainable agriculture.

4. Conclusions
The application of liquid organic fertilizers and 75% recommended inorganic fertilizers (15 ml per 2 L water + NPK Phonska 300 kg ha$^{-1}$ + Urea 150 kg ha$^{-1}$) can be the recommended dosage for optimum maize production due to the improvement of plant growth parameters and yiled.

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