

# The Effect of Polyglutamic Acid Produced from Glutamic Acid Wastewater on Maize Growth

Fujia Li<sup>2</sup>, Chen Zhao<sup>2,3,4</sup>, Kunlun Li<sup>2</sup>, Qiulin Yue<sup>4</sup>, Le Su<sup>4</sup>, Baojun Li<sup>2</sup>, Xin Sun<sup>4</sup>,  
Haijun Li<sup>6</sup>, Suzhen Yang<sup>5</sup>, Lei Sun<sup>1</sup>, Lin Zhao<sup>1,4,\*</sup>

<sup>1</sup>Shandong Baoyuan Biotechnology Co., Ltd, Yantai 264000, China

<sup>2</sup>Jinan Hangchen Biotechnology Co., Ltd, Jinan 250001, China

<sup>3</sup>Yuan Tan Environmental Technology (Shandong) Co., Ltd, Jinan 250001, China

<sup>4</sup>Qilu University of Technology (Shandong Academy of Sciences), Jinan 250300, China

<sup>5</sup>Shandong Freda Biological Co., Ltd, Jinan 250101, China

<sup>6</sup>Shandong Furuida Biotechnology Co., Ltd, Linyi 276700, China

## Abstract

**This experiment uses polyglutamic acid water-soluble fertilizer produced from glutamic acid fermentation waste liquid as the experimental fertilizer to study its impact on maize yield and quality in maize cultivation. The results showed that compared to farmers who are accustomed to fertilization, the application of the new water-soluble polyglutamic acid fertilizer reduced the bald head length of corn by 0.7 cm; The weight of 100 grains of corn increased by 0.7g, resulting in an increase of 26.7 kilograms of corn per mu, with a yield increase of 5%.**

## Keywords

**Glutamic Acid Waste Liquid; Polyglutamic Acid; Fertilizer; Corn; Production.**

## 1. Introduction

A biostimulant is a substance containing certain ingredients and/or microorganisms that, when applied around the root system of a plant, stimulate the natural processes of the plant, including enhancing/benefiting nutrient absorption, nutrient efficacy, abiotic stress resistance and crop quality. Internationally widely used biostimulants are divided into 8 categories: microorganisms, humic acids, alginic acids, amino acids, chitin chitosan, inorganic salts (ammonium polyphosphate, phosphite), beneficial chemical elements and anti-transpirants[1]. Polyglutamic acid ( $\gamma$ -PGA) is a water-soluble polyamino acid produced by microbial fermentation, which is composed of single glutamic acid molecules linked by amide bonds. With excellent water retention, it can balance soil pH value in agricultural production, combine and precipitate toxic heavy metals, enhance plant disease resistance and stress resistance, and promote yield increase. It can be used in agricultural production as soil water retaining agent, seed germination promoter, fertilizer and pesticide synergist[2]. Studies have found that  $\gamma$ -PGA can regulate soil microorganisms, enrich beneficial microorganisms, and increase the contents of total nitrogen, total phosphorus and total potassium in soil [3];  $\gamma$ -PGA can be used as a transport belt between roots and nutrients, which significantly improves the absorption and utilization rate of fertilizers by plants. The degraded product glutamic acid can also be used as a nutrient for plants[4]

$\gamma$ - The preparation methods of PGA include chemical synthesis, extraction, microbial fermentation, and enzyme conversion. Currently, the production of polyglutamic acid mainly relies on fermentation, which is produced by microorganisms such as *Bacillus licheniformis* and

*Bacillus subtilis* using glutamic acid and glucose as raw materials[4]. The traditional production of  $\gamma$ -polyglutamic acid requires the fermentation of high value raw materials such as glutamic acid and glucose, and the solid product is prepared by alcohol extraction and drying, which has high cost of fermentation and extraction. In 2023, China's demand for polyglutamic acid exceeded 22,000 tons. However, the traditional  $\gamma$ -polyglutamic acid fermentation production has significant problems of high production cost and low extraction yield, which greatly restricts the popularization and application of polyglutamic acid in agriculture.

This article is based on the patent "ZL202010647427.6 salt-tolerant *Bacillus licheniformis* A-A2-10, its application and application method"[5]. Polyglutamic acid is synthesized from residual total sugars and glutamic acid in the isoelectric crystallization mother liquor of glutamic acid, and an ion complexation flocculation process is used to achieve low-cost preparation of polyglutamic acid powder products. The yield of polyglutamic acid can reach over 98%. Then, based on the study of complex solvent composition, low-cost agricultural water-soluble polyglutamic acid products were obtained, and product fertilizers were designed for field application effect experiments to study their impact on corn growth, in order to provide a basis for the application and promotion of polyglutamic acid in agricultural planting

## 2. Materials and Methods

### 2.1. Location of the Experiment

Da Cuizhuang Village, Zhangjialou Town, Huangdao District, Qingdao City, Shandong Province

### 2.2. Time of the Experiment

The experiment was conducted from July 15th to October 15th, 2021

### 2.3. Soil for the Experiment

Brown soil with medium fertility level. Before the test, soil samples were taken for laboratory analysis to understand the basic conditions of the test plot. The test results are shown in Table 1. The comprehensive evaluation of soil test results showed that the soil fertility of the test was medium to above.

**Table 1.** Physico-chemical conditions of the tested soil

pH	Alkali hydrolyzed nitrogen(mg/kg)	Available phosphorus(mg/kg)	Rapidly available potassium(mg/kg)	Organic matter(g/kg)
6.7	78.85	31.25	105.38	13.60

### 2.4. Fertilizer for the Experiment

Polyglutamic acid water-soluble fertilizer, with glutamic acid fermentation waste liquid as raw material, according to the patent "ZL202010647427.6 salt-tolerant *Bacillus licheniformis* A-A2-10, its application and application method", with *Bacillus licheniformis* A-A2-10 as the strain. Polyglutamic acid fertilizer was prepared by using the residual glutamic acid in glutamic acid wastewater, and the content of polyglutamic acid was 2.8%

### 2.5. Crop for the Experiment

Crop for test: Corn, variety Denghai 605.

### 2.6. Design of the Experiment

Three treatments were set up in the experiment, without repetition. Each treatment cell was 10 meters long and 6 meters wide, with an area of 60m<sup>2</sup>, and 10 rows of corn were planted.

Treatment 1: Customary fertilization by farmers

Treatment 2: On the basis of farmers' customary fertilization, 1.7 kg of water-soluble polyglutamic acid fertilizer was applied per mu.

Treatment 3: On the basis of farmers' customary fertilization, 3.3 kg of water-soluble polyglutamic acid fertilizer was applied per mu.

Customary fertilization by farmers: 50 kilograms of corn formula fertilizer (containing 28% nitrogen, 6% phosphorus, and 11% potassium) per acre. Other management measures are the same as normal management for farmers.

## 2.7. Test Method

### 2.7.1. Test Method

Corn was sown on June 18th, and corn specific fertilizer was applied simultaneously. Experimental fertilizer was applied on July 15th. Application method: Accurately weigh the experimental fertilizer according to the experimental design, dilute it to 5 kilograms with water, dig a hole 10cm on one side of the corn seedling, pour the diluted experimental fertilizer into the hole, and then cover it with soil.

Harvest on September 29th, select 3 rows of corn for each community, harvest each row separately, and bring it back to the drying site for drying. On October 25th, investigate the yield traits related to corn and calculate yield by threshing.

## 3. Result Analysis

### 3.1. The Effects of Different Treatments on Maize Traits

On October 25th, after the corn ears were air dried, an investigation was conducted on the length, number of rows, number of grains per row, bald head length, and hundred grain weight of the corn ears. The results of the investigation are shown in Table 2.

**Table 2.** Effects of Different Treatments on Corn Yield Traits

Treatment	Ear length(cm)	Row number of ear(row)	Grains per row (grain)	Bald head length (cm)	Hundred-grain weight (g)
1	17.8	16.5	37.8	1.4	34.3
2	17.7	18.0	38.4	0.7	35.0
3	18.0	17.2	37.8	0.8	34.6

According to the data in Table 2, different amounts of experimental fertilizer had no significant effects on ear length, row number of ear, and row grain number of corn, and the investigation data of each experimental treatment were basically consistent.

Different fertilization treatments had certain effects on the bald head length of corn. In each treatment of experimental fertilizer application, the bald head length was lower than that of farmers' customary fertilization. Among them, treatment 2 (1.7 kg of polyglutamic acid water-soluble fertilizer applied per mu) had the lowest bald head length, which was 0.7 cm lower than treatment 1 (farmers' customary fertilization). Treatment 3 (3.3 kg of water soluble polyglutamic acid fertilizer per mu) reduced the bald head length by 0.6 cm compared with treatment 1 (farmers used to apply fertilizer), indicating that the experimental fertilizer had a certain effect on promoting corn pollination, and different application amounts had little effect on the bald head length.

Compared with treatment 1 (farmer's customary fertilization), the hundred-grain weight of corn increased to a certain extent in all treatments treated with experimental fertilizers. Among them, treatment 2 (using 1.7 kilograms of polyglutamic acid water-soluble fertilizer per mu) had a 0.7 gram higher hundred-grain weight than treatment 1 (farmer's customary fertilization). There is not much difference in the weight of corn kernels with different dosages for the same product.

### 3.2. Effects of Different Treatments on Maize Yield

On October 25, the corn was threshed and the yield was calculated. The influence of different treatments on the corn yield was shown in Table 3.

**Table 3.** Effects of different treatments on maize yield

Treatment	Yield with different repetitions (kg/mu)			Average (kg/mu)	Increased production(kg/mu)	Increased production(%)
	Repeat1	Repeat2	Repeat3			
1	567.0	533.6	506.9	535.8	0.0	0.0
2	578.1	522.5	587.0	562.5	26.7	5.0
3	533.6	589.2	554.9	559.2	23.4	4.4

According to the data in Table 3, the yield of corn applied with experimental fertilizer was higher than that used by farmers' customary fertilization, indicating that experimental fertilizer had a certain effect on increasing the yield of corn. Among them, the corn yield of treatment 2 (1.7 kg per mu of polyglutamic acid water-soluble fertilizer) was the highest, increasing corn yield by 26.7 kg per mu, and the increase rate reached 5%. Treatment 3 (3.3 kg per mu of polyglutamic acid water-soluble fertilizer) increased corn yield by 23.4 kg per mu, with a yield increase of 4.4%. There was little difference in corn yield when different amounts of fertilizer were applied.

## 4. Conclusion

This study found that the bald head length of corn ears in all treatments treated with experimental fertilizers was lower than that of farmers who were accustomed to fertilization. Applying 1.7 kilograms of polyglutamic acid water-soluble fertilizer per mu reduced the bald head length by 0.7cm compared to farmers who were accustomed to fertilization. The hundred grain weight of corn in all treatments treated with experimental fertilizers was 0.7g higher than that of the cContrast treatment; The application of new fertilizers can increase the total yield of corn, with a maximum increase of 5% compared to the Contrast treatment.

$\gamma$ -PGA has a good plant growth promoting and efficiency enhancing effect, which can organize the combination of fertilizer nutrients and soil trace elements, increase the content of soil nitrate nitrogen and ammonium nitrogen, as well as the number of root zone soil microorganisms and soil enzyme activity, promote plant nutrient absorption, increase dry matter and nutrient accumulation, and thus improve yield. Dou Jingang et al. found that the application of polyglutamic acid water retaining agent increased maize yield by 2.54%; Diao Qian et al. found that 2%  $\gamma$ -Polyglutamic acid fertilizer increased the 100 grain weight of corn by 0.8g and the yield by 6.4%; these conclusions are basically consistent with this study.

## Acknowledgments

[Fund Project] Key R&D Plan of Shandong Province (Mount Taishan Industrial Leading Talent Project High efficiency Ecological Agriculture Innovation)(LJNY202015);Special funds for the central government to guide local scientific and technological development (YDZX2021051); Financial Science and Technology Plan Project of the Xinjiang Production and Construction Corps (2022AB002); Qiqihar City "Unveiling the List and Leading the Way" Science and Technology Research Project(JBGS-202104);National Key R&D Program (2023YFE0111900); Key R&D Plan of Shandong Province(2022SFGC0301);Science and Technology Plan of Jinan (202131004).

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