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Effect of New Low-cost Polyglutamic Acid fertilizer on Cucumber Growth

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Abstract

Polyglutamic acid produced from the mother liquor of glutamic acid crystals was used as a test fertiliser to study its application in cucumber cultivation. The results showed that the application of polyglutamic acid fertiliser could increase cucumber plant height, plant pitch, number of leaves, root dry matter weight, promote cucumber growth, increase cucumber single melon weight and total yield, and at the same time, it could increase the content of Vc and soluble sugar in cucumber fruits and improve the quality of cucumber. Among them, the application of polyglutamic acid fertiliser increased the plant height of cucumber by 6.3%-39.5% during the flowering period, increased the plant height by 1.8%-12.1% during the melon blooming period, increased the root dry matter weight by 92.8%, increased the weight of single melon by 4.01%-37.12%, and increased the total output by 1.31%-12.87%; the application of two polyglutamic acid fertilisers increased the vitamin C of cucumber fruits by 14.36 % and 28.12 %, and the soluble sugar content by 16.91 % and 35.29 %.

Keywords

Glutamic Acid Waste Liquid; Polyglutamic Acid; Fertilizer; Cucumber; Production; Quality.

1. Introduction

γ-polyglutamic acid (γ-PGA) is a single glutamic acid molecule connected by amide bonds to form polyamino acids, it has excellent water retention, adsorption and biodegradability, after application in the soil, through water retention, chelation, it can promote the absorption of nitrogen, phosphorus, potassium and other fertilizer factors. After being absorbed by plants, it can effectively enhance crop disease resistance and stress resistance, and promote the growth and enrichment of agricultural probiotics in soil, balance soil pH, and reduce heavy metal pollution. At present, polyglutamic acid has been widely used in agricultural production as a new green farmland input[1]

The preparation methods of γ-polyglutamic acid include chemical synthesis, extraction, microbial fermentation, and enzyme conversion. The biological fermentation method has become the main method for the industrial production of polyglutamic acid, which uses strains such as Bacillus licheniformis and Bacillus subtilis as production strains, ferments and synthesizes glutamic acid and glucose as raw materials, and then prepares polyglutamic acid powder products through alcohol extraction and other technologies[2]. In 2023, China's demand for polyglutamic acid exceeded 22,000 tons. However, the traditional γ-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[3]

In this study, according to the patent "ZL202010647427.6 salt-tolerant Bacillus licheniformis A-A2-10, its application and application method"[4], polyglutamic acid was synthesized from the total sugar and glutamic acid remaining in the mother liquid of electrocrystallization of glutamic acid, and the low-cost preparation of powdered polyglutamic acid products was realized by adopting the ion complex flocculation process.The yield of polyglutamic acid was more than 98%.In this study, cucumber was used as the test crop to study the agronomic effect of polyglutamic acid powder product resolution, in order to lay a foundation for the popularization and application of this kind of polyglutamic acid powder product in agricultural planting.

2. Materials and Methods

2.1. Location of the Experiment

The experiment was conducted at the Wuqing Innovation Base of Tianjin Academy of Agricultural Sciences. The greenhouse was 60 meters long and 12 meters wide, with an effective planting area of 1.0 mu. The experimental greenhouse has a flat terrain and uniform fertility, with spinach as the previous crop.

2.2. Time of the Experiment

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

2.3. Soil for the Experiment

The soil is tidal soil, and the basic physical and chemical properties of the soil are shown in the table below:

Table 1. Physico-chemical properties of 0-20 cm soil below the test site

pH	Organic matter /(%)	Total salt /(%)	Hydrolyzable nitrogen /(mg/kg)	Available phosphorus /(mg/kg)	Available potassium /(mg/kg)
8.1	3.43	0.293	179.00	94.91	355.50

2.4. Fertilizer for the Experiment

Fertilizer A: Commercial liquid polyglutamic acid products(about 3.5% PGA content)

FertilizerB:Polyglutamic acid powder complex solution,Using glutamic acid isoelectric crystallization mother liquor as the raw material, a powdered product with a polyglutamic acid content of 25% was prepared according to the patent"ZL202010647427.6 salt-tolerant Bacillus licheniformis A-A2-10, its application and application method", 20% potassium hydroxide was added for re dissolution, and the polyglutamic acid content in the solution was 1%.

2.5. Crop for the Experiment

Crop for test:Cucumber,variety Kerun 99,provided by Institute of Cucumber Research lnstitute,Tianjin Academy of Agricultural Sciences.

2.6. Design of the Experiment

Two fertilizer varieties were designed for the experiment, with three different dosages for each fertilizer variety. A total of seven experimental treatments were designed. They are: treatment

1 control (blank), treatment 2 fertilizer A with a dosage of 0.625 kg/mu (A1), treatment 3 fertilizer A with a dosage of 1.25 kg/mu (A2), treatment 4 fertilizer A with a dosage of 2.5 kg/mu (A3), treatment 5 fertilizer B with a dosage of 2.5 kg/mu (B1), treatment 6 fertilizer B with a dosage of 5.0 kg/mu (B2), treatment 7 fertilizer B with a dosage of 10.0 kg/mu (B3). Each process is repeated 3 times, randomly arranged, with a community area of 4 meters×5 m=20 m^2. The field management measures such as watering, weeding, and pest control were consistent for each treatment in the experiment.

2.7. Experimental Measurement Items and Methods

2.7.1. Test Method

The experiment was conducted on the basis of local conventional fertilization. The conventional fertilization was as follows: 1500 kg/mu of basic organic fertilizer, 40 kg/mu of compound fertilizer (18-18-18), and 3 times of top dressing during cucumber growth period. The top dressing fertilizer was Huangbo 2 (19-6-25), with a total amount of top dressing of 45 kg/mu.

On July 15, 2021, the land was leveled, and bottom fertilizer was applied on July 20. From July 22 to 25, the furrow was made. On July 26, the seeds were sown and watered, and the seedlings were set on July 30. Plant 6 rows and 13 trees per row in each residential area.The large row spacing was 1.3 meters, the small row spacing was 40 centimeters, the plant spacing was 30 centimeters and the density was 2600 plants/acre.The melons were picked on September 3, finished on October 6, and the seedlings were pulled on October 15. Continuous cloudy and rainy weather during the National Day period had a significant impact on cucumber experiments.

During the entire growth period of cucumbers, a total of 4 applications of growth promoting fertilizers were applied, including the first application after cucumber sowing on July 27th (fertilizer A and fertilizer B were added at 20% of the design amount and washed with water), the second application during the early melon stage on September 7th (fertilizer A and fertilizer B were added at 30% of the design amount and washed with water), and the third application during the full melon stage on September 17th (fertilizer A and fertilizer B were added at 30% of the design amount and washed with water) On September 22nd, the fourth round of flushing application will be carried out during the late melon season (fertilizer A and fertilizer B will be added at 20% of the designed dosage and flushed with water).

2.7.2. Determination of Cucumber Yield

The cucumber yield was measured from September 3, 2021 to October 6, 2021, using actual harvest measurement and electronic platform scales.

2.7.3. Determination of Cucumber Quality

The Vc content, NO3-N content, and soluble sugar content of cucumber fruit were analyzed. The vitamin C content of the fruit was determined by high-performance liquid chromatography (GB 5009.86-2016)[5],the NO3-N content was determined by salicylic acid colorimetry[6], and the soluble sugar content was determined by copper reduction iodine method (NY/T 1278-2007) [7].

3. Result Analysis

3.1. The Effect of Promoting Fertilizer Application on Cucumber Yield

3.1.1. The Effect of Promoting Fertilizer Application on the Weight of Cucumber Per Melon

Statistics were conducted on the weight of individual cucumbers in each treatment, and the results are shown in Table 6. It can be seen that the application of growth promoting fertilizers can increase the weight of cucumbers per unit. Compared with the control, the weight of cucumbers per unit increased by 5.75-53.24 g, with an increase of 4.01% -37.12%. In fertilizer A treatment, the A1 dosage treatment had the highest single melon weight, which was 180.49 g, with an increase of 25.84%; In fertilizer B treatment, the B3 dosage treatment had the highest single melon weight at 196.67 grams, with an increase of 37.12%

Table 2. Effect of growth-promoting fertiliser application on the weight of single melon in cucumber

Treatment	Single cucumber weight / g				Increment	
	I	II	III	Average	g	%
CK	153.74	125.95	150.59	143.43	-	-
A1	161.76	181.95	197.76	180.49	37.06	25.84
A2	146.58	145.07	157.04	149.56	6.13	4.28
A3	149.03	143.95	154.56	149.18	5.75	4.01
B1	170.70	172.85	185.97	176.50	33.07	23.06
B2	150.13	159.32	152.48	153.97	10.54	7.35
B3	181.50	198.76	209.77	196.67	53.24	37.12

3.1.2. Effect of Growth Promoting Fertilizer Application on Total Yield of Cucumber

The cucumber yield of each treatment was statistically analyzed, and the results are shown in Table 7. It can be seen that the application of growth promoting fertilizers can increase cucumber yield, with an increase of 35.3-346.9 kg/mu compared to the control, with an increase of 1.31% -12.87%. The cucumber yield in the control treatment was the lowest, at 2696.7 kg/mu. In fertilizer A treatment, the A1 dosage treatment had the highest yield increase, at 2942.7 kg/mu, with an increase of 9.12%; In fertilizer B treatment, the B3 dosage treatment had the highest yield increase, reaching 3043.6 kg/mu, with an increase of 12.87%.

Table 3. Effect of growth promoting fertiliser application on cucumber yield

Treatment	Yield kg/ mu				Increment	
	I	II	III	Average	kg/ mu	%
CK	2770.4	2254.8	3064.9	2696.7	-	-
A1	2893.6	3026.5	2908.1	2942.7	246.0	9.12
A2	2602.3	2889.1	2704.4	2731.9	35.2	1.31
A3	2879.8	2290.8	3146.2	2772.3	75.6	2.80
B1	2889.8	2580.0	2928.8	2799.5	102.8	3.81
B2	2897.4	2361.8	3139.6	2799.6	102.9	3.82
B3	2698.7	3207.3	3224.9	3043.6	346.9	12.87

3.2. Effect of Growth Promoting Fertilizer Application on Cucumber Quality

The analysis of Vc content, NO3-N content, and soluble sugar content in cucumber fruits is shown in Table 8. It can be seen that compared with the control treatment, the application of growth promoting fertilizers in all treatments can increase the Vc content and soluble sugar content of cucumber fruits to varying degrees. The control treatment had the lowest Vc content in cucumber fruit, which was 117 mg/kg. The Vc content in cucumber fruit treated with A1 dosage in fertilizer A was 133.8 mg/kg, with an increase of 14.36%. In fertilizer B treatment, the Vc content in cucumber fruit treated with B3 dosage was 149.9 mg/kg, with an increase of 28.12%. The control treatment had the lowest soluble sugar content in cucumber fruits, which was 1.36%. The soluble sugar content in cucumber fruits treated with A1 and B3 was 1.59% and 1.84%, respectively, with an increase of 16.91% and 35.29%.

Table 4. Effect of growth promoting fertiliser application on cucumber fruit quality

Treatment	Vc (mg/kg)	NO_3-N (mg/kg)	Total soluble sugar (%)
CK	117.0	93.80	1.36
A1	133.8	90.32	1.59
A2	128.7	97.28	1.49
A3	133.8	103.1	1.50
B1	123.6	100.3	1.61
B2	130.7	101.0	1.45
B3	149.9	112.8	1.84

4. Conclusion

This study found that the application of new fertilizers can increase the weight and total yield of cucumbers. Compared with the control treatment, the weight of cucumbers increased by 5.75-53.24 g, with an increase of 4.01-37.12%, and the total yield increased by 35.3-346.9 kg/mu, with an increase of 1.31-12.87%. The content of vitamin C and soluble sugars is an important indicator for measuring the quality of cucumber. Compared with the control group, the application of two types of polyglutamic acid fertilizers increased the vitamin C content of cucumber fruits by 14.36% and 28.12%, and the soluble sugar content by 16.91% and 35.29%. Effectively improved the quality of cucumber.

This may be due to the fact that γ-PGA has a good plant growth promotion and synergistic effect, which can organize the combination of fertilizer nutrients and soil trace elements, promote the development of plant roots in the early growth stage, thus promoting the absorption of nutrients by crops and improving the accumulation of nutrients by plants, thereby improving fruit yield and quality. He Yu et al. found that γ-PGA and γ-PGA fermentation solution increased the yield of green vegetables by 20.20% and 37.63%; Tong Yana et al. found that the average fruit weight, average yield, soluble solids, titrable acid and soluble sugar contents of strawberry combined with a certain amount of γ-PGA were higher than those of control; Zhang Mengjun et al. found that the application of water-soluble fertilizer containing polyglutamic acid granules increased the content of soluble sugars and vitamin C in cauliflower by 11.05% and 8.69%.These are basically consistent with the conclusions of this study.

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