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Effects of Plasma Treatment on Plant Growth and Yield of Green Bean Seeds

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ABSTRACT

Plasma treatment of seeds at atmospheric pressure is a new technology, through its activation of seed endogenous substances, so that crops improve disease resistance, thereby increasing yield. Using plasma seed processor to treat the seeds of green bean (Jiadouwang), the test was carried out with different doses (200 mA~1600 mA).The results showed that the growth and development of green bean were significantly improved by comparing different plasma doses treated with the untreated CK. and the treatment current (dose) of 1000 mA、1200mA and 1400 mA of plant traits were significantly changed. The plasma treatment with different doses (current 200 mA~1600mA) can promote the yield of green beans, especially, the yield effect of the appropriate dose (1000 mA) was extremely significant, the plasma current treatments 600 mA、800mA、1400mA had a significant effect on the yield of green beans. The trend prediction of single pod yield was basically consistent with the actual test data. The disease resistance of green beans after proper dose (600 mA~1600 mA) plasma treatment was better than that of untreated CK. In brief, the effect of different doses of plasma treatment on the biological properties of green bean was different. The plant traits of green bean by proper plasma treatment were significantly improved compared with the control (CK), and the disease resistance of treated green bean was also better than that of untreated (CK). The yield of green bean in the eight treated groups could be improved by plasma treatment with different dosage.

Keywords: *Plasma, Green bean, Seed, Plant traits, Yield.*

INTRODUCTION

At present, physical technology has been widely used in agriculture, plasma treatment of seeds at atmospheric pressure is a new technology, through its activation of seed endogenous substances, so that crops improve stress resistance, thereby increasing yield.

The breeding of traditional crops especially vegetables adopts traditional breeding methods with long cycle and low efficiency. Plasma processing seed technology, is the application of physical methods in agriculture, the cost is lower than the cost of biological agents and chemical agents to treat seeds, and do not pollute the environment. The application of plasma technology in agriculture has a broad prospect. Zhou *et al.* (2009, 2010, 2011), Huang and Zhou (2011) used atmospheric pressure dielectric barrier plasma discharge at room temperature for some vegetables (tomato, eggplant, *etc.*) seed treatment a decade ago, including the Chinese academy of sciences institute of physics for chilli (Chen *et al.*, 2005), lettuce (Wang *et al.*, 2007), cucumber (Wang *et al.*, 2007) and other crops to do plasma irradiation technology research, have achieved better results. These techniques mainly use atmospheric pressure dielectric barrier discharge plasma to produce high pressure outside the parallel plate, by adjusting different high pressure to achieve the treatment of different plasma dose of plant seeds, the related vegetable plants have better stress resistance and yield effect. In recent years, high-voltage arc ionization of air nitrogen and oxygen molecules has been used to produce plasma irradiation combined with alternating inductance, by adjusting the different current treatment of some seeds(Fang *et al.*, 2004, Ma *et al.*, 2010, Geng*et al.*, 2014), but it has been found that the treatment group is not many, the current interval stage is large, the treatment dose is rough, and it is easy to lose some plant biological properties due to the small dose (small current change). In this study, the DL-2 plasma seed processor was

used to treat the seeds before crop sowing. This technology is to draw lessons from the physical effects of space plasma on seeds in space breeding.

In the form of free fall, the seeds have been subjected to short-time light irradiation, inductive action and ozone sterilization to stimulate the potential of seeds, enhance the vigor of seeds and improve the robustness of seeds. After the seeds were treated, the crops had good characters, strong growth and disease resistance, and increased crop yield. therefore, using atmospheric pressure plasma as a new type of seed treatment technology, the combined action of multiple factors will be beneficial to the improvement of varieties, and the technology is carried out at atmospheric pressure under normal temperature without vacuum equipment, easy to operate, low cost, and no damage to plant seed cells. Our research group treated solanaceae seeds (eggplant, tomato) with plasma treatment with different high pressure (4760V~6800V, 4420V~6800V) atmospheric pressure dielectric barrier discharge technology in the original study. On the basis of plasma different currents (200mA~1600mA) were used to treat green bean seeds (Jiadouwang), which were tested in nine groups, eight plasma treatment groups and one untreated group (CK). the plasma treatment dose was subdivided into 200mA, to observe the changes of plant traits, disease resistance and yield of nine groups. Through mathematical statistics analysis, we can select the best treatment dose of plasma seed treatment to improve the yield of green bean. This research provides new technical support for improving yield of green bean and improving efficiency of agricultural production.

Materials and Methods

Materials

The experiments were carried out in the Jinmandi Horticulture Science and Technology Test Field in Penglai Township, Baiyun District, Guiyang City, Guizhou Province, in China, and in the Plasma Laboratory of the Institute of Physics and Electronic Science, Guizhou Education University. The plasma-to-seed treatment device uses a DL-2 plasma seed processor. The test material is green bean (Jiadouwang) seeds.

Device

A plasma seed processor device DL-2 Dalian Bosi Plasma Co., Ltd was used in this test to treat green bean seeds. The schematic diagram is shown in Figure 1 power:<1.2kw; flow rate: =">1500kg/h; rated voltage: 220V; frequency: 50Hz; current adjustment range: 0~3.5A; adjustable precision: 100mA. When processing, after power on, pull the lower part of the machine air protection switch to the on (ON) position, the voltage indicator pointer swings to the right, showing the supply voltage, up press the plasma switch, the switch is bright, the circuit is on, the plasma emitter in the machine starts, the plasma indication is bright, then the light green light is reflected at the upper feed port of the machine. If the plasma radiant tube does not start, the plasma warning sounds, when the point presses the plasma start button ("point presses" don't hold down, it is pressed, released, pressed again, released again...) until the start of the plasma radiant tube, warning to stop the call. After starting the preheating for 8 min, press the strength switch up to adjust the desired current value by rotating the coarse adjustment and fine-tuning knob. The method of seed treatment is self-flowing, the seed does not stay in the machine, the seed is added from the top feed funnel, and the seed from the outlet must keep the seed flowing smoothly, keep the flowing speed of the seed, and the slow flow rate will affect the effect of seed treatment. The plasma treated seeds were treated once from pouring to receiving, and the number of treatments was 3 times.

Methods

Plasma Experiment Method

Plasma seed treatment in a total of 9 groups, 8 treatment groups, and 1 control (CK) group (or untreated group). The seeds were treated with different current by adjusting dosage. The treatment current was 200mA, 400mA, 600mA, 800mA, 1000mA, 1200mA, 1400mA, 1600mA compared with seeds without any treatment (CK). Eight groups were treated three times according to the above dose. Figure 2shows the growth of green beans treated with different doses of plasma in field, and Figure 3 shows the growth of green bean untreated group CK (control) in field under the same external environment.

Test Method in Field

Field test design total area 667m^2. Line spacing 80cm, plant spacing 50cm, base fertilizer compound fertilizer, the whole growth period topdressing 2 times, leaf surface fertilizer 3 times and with headache powder, amoxicillin pest control. Only a small amount of leaf surface rust spots, through leaf mesh headache powder, can be controlled. Plant traits, yield traits, disease resistance and growth period were recorded.

Figure1. *Schematic diagram of the DL-2 plasma seed processing device*

RESULTS AND DISCUSSION:

Effects of Plasma Treatment with Different Dose (Current) on Plant Traits of Green Beans

Effects on the Stem course of Green bean

Effects on the stem coarse of green bean from the plant traits in Table I: the results showed that the plasma treatment of 8 groups increased (0.2~0.5cm) compared with untreated group CK. Treatment groups No. 5, 6, 7, 8 increased significantly, the other treatment groups were 0.3 cm. higher than the untreated CK.

Effects on the Number of Branches of Green beans

After plasma treatment, the effect of branch number of 8 groups was that there was no change in treatment groups No. 2, 3 and 8, the number of branches of treatment groups No. 4, 5, 6 and 7 increased by 1 (contrast CK), but the number of branches of treatment group No. 1 decreased by 1.

Effect on the Node position of the First inflorescence of Green bean

Node position of the first inflorescence of the plasma treatment groups were affected, For the treatment groups No. 1, 3, 5, their first inflorescence was decreased compared with CK group, no change in other treatment groups.

Effects on the Fruit number of per Inflorescence of Green beans

Effect of the fruits of inflorescence per inflorescence in the eight groups treated by plasma, except for treatment group No. 1, the fruit number of per inflorescence of the other treatment groups increased by 2 than the control CK.

Effect on the Length of Single pod in Green bean

Except for no change in treatment No. 1, the single pod length of the seven groups treated by plasma increased to varying degrees compared with the control CK (1cm~4cm), the longer increasing was No. 4~No. 8 groups.

To sum up, different dose plasma treatment of green bean seeds, resulting in different degrees of impact on green bean stem coarse, number of branches, node position of the first inflorescence, of fruits per inflorescence, single pod length plant traits, and each botanical character index of number different dose plasma treatment is also different, most indicators change significantly, a few are not obvious or no change. All in all, the growth and development of green beans were obviously promoted by proper plasma treatment at different doses (compared with CK), especially the treatment group with significant changes in the influence of green bean plant traits was the No. 5, No. 6 and No. 7 groups.

Effect of Plasma Treatment with Different Dose (Current) on Disease Resistance of Green Bean

From Table 1, disease resistance: compared with untreated (CK), no viral rust spots were found in six groups (No. 3, 4, 5, 6, 7, 8) treated by plasma except treatment groups No. 1, 2 and control group CK. The reason may be due to insufficient plasma treatment dose in treatment groups No. 1 and 2. All nine groups (8 treatment groups and 1

CK group) had no leaf mold and powdery mildew. The fertility period of the other 6 treatment groups (groups No. 3, 4, 5, 6, 7, 8) was 5~10 days longer than that of the CK group, except for the first, second and CK groups, which had about 100 days. Overall, proper dose (600mA~1600mA) plasma treatment showed better resistance to disease than untreated CK.

Effects of Different Doses of Plasma Treatment on Yield Traits of Green Bean

The yield traits in Table 1: Compared with untreated (CK), the yield of single pod in all 8 groups treated by plasma was higher than that in control (CK), and the yield of single pod in 8 groups increased 1kg~3kg. The first two highest yield were: treatment group No. 5 single pod yield 9 kg~13kg (plasma dose 1000mA), treatment group No. 7 pod yield 8 kg-13kg (plasma dose 1400mA), corresponding to single pod yield 28.57%~30%, 14.28%~30% higher than CK, respectively. Lowest single pod yield also increased by 14.28% (plasma dose 200mA). From the start-up period, the start-up period of all 8 groups treated by plasma was 2~6 days more than that of untreated CK. To sum up, plasma treatment with different doses (plasma current 200mA~1600mA) can promote the growth, development and yield of green bean, in which the treatment yield effect of appropriate dose (1000mA) is extremely significant, and the plasma current treatment 600mA, 800mA, 1400mA has a significant effect on green bean yield.

Figure2. *(Color online) The growth of green beans treated with different doses of plasma in field*

Table1. *Record of Effects of Plasma Treatment on Green Bean*

Groups No.	Dose	Planttraits					Yield traits		Pest/plant			Fertility traits
	Current (mA)	Stem coarse (cm)	Number of branches (each)	Node position of first inflorescence (each)	Fruit number per Inflorescence (each)	Single pod length (cm)	Yield (kg)	initial collection period (day)	viral rust spots	leaf mold	powdery mildew	growth stage (day)
1	200	0.8~1.5	3~4	4~5	2~6	12~16	8~10	38	√			90~100
2	400	0.8~1.5	3~5	4~6	4~6	13~17	8~11	40	√			100
3	600	0.8~1.5	3~5	4~5	4~6	14~18	9~12	40				100~105
4	800	0.8~1.5	3~6	4~6	4~6	14~19	9~12	42				100~105
5	1000	0.8~2.0	3~6	4~5	4~6	13~20	9~13	40				100~110
6	1200	0.8~2.0	3~6	4~6	4~6	13~19	8~12	40				100~110
7	1400	0.8~2.0	3~6	4~6	4~6	13~19	8~13	40				100~106
8	1600	0.8~2.0	3~5	4~6	4~6	13~19	8~12	40				100~106
9	0	0.5~1.5	3~5	4~6	4	12~16	7~10	36	√			100

Figure3. *(Color online) The growth of green beans untreated group CK (control) in field under the same external environment*

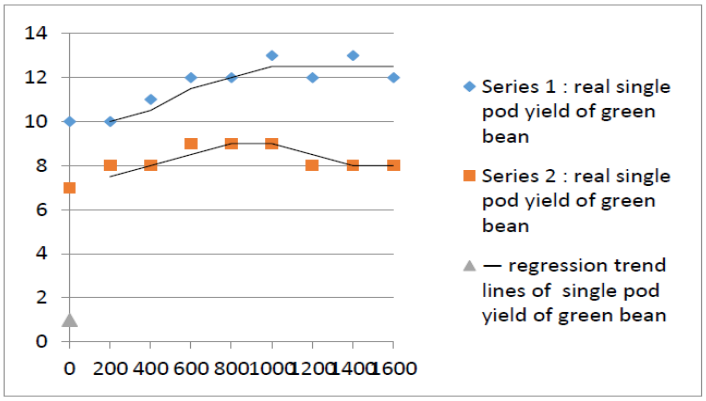

Figure4. *(Color online) Mathematical statistics of yield trend of green bean by plasma treatment with different doses*

Mathematical Statistics of Yield Trend of Green Bean by Plasma Treatment with Different Dosage

Mathematical and statistical analysis of yield (Series 1) trend of green bean single pod

The results showed that the yield of single pod was predicted from the regression trend line (see Figure4 blue dot line). The relationship between single pod yield and plasma current treatment (regression equation) was in accordance with the two-period average moving distribution. The first peak appeared at (1000mA) and the second at (1400mA). The results showed that the two treatment groups (groups No. 5 and 7) with the selected plasma dose of 1000mA and 1400mA were the most productive for single pod. The trend prediction of single pod yield is basically consistent with the actual test data.

Mathematical and statistical analysis of yield (Series 2) trend of green bean single pod

The mathematical statistical analysis of yield of single pod (series 2) was performed after the treatment of unequal ion doses.(see Figure 4 red dot line): prediction of green bean from regression trend line: the relationship between yield of single pod and plasma current treatment (regression equation) is basically in accordance with the Gaussian distribution law, which is consistent with our previous research prediction (Zhou *et al.*, 2009, 2010, 2011). The yield of green bean was greatly improved after plasma treatment of seeds with an appropriate plasma dose range of 600mA~1000mA (groups No. 3, 4, 5). The peak of Gaussian distribution prediction appears around 800mA~1000mA, and the yield trend prediction is basically consistent with the actual test data.

Conclusion

It is undoubtedly of great economic and strategic significance to use high voltage arc ionization air nitrogen and oxygen molecules to produce plasma irradiation and alternating inductance to treat plant seeds by adjusting different current (dose), to change their growth law, to improve product quality and to increase local crop yield. This kind

of applied research has a good prospect for solving some key technical problems in national economy and social development. It can provide a possible and effective way for more crops to increase production, and also can build a technical platform for the improvement of traditional agricultural breeding technology means and the application of high and new technology in agricultural breeding. In particular, the application of plasma technology to agricultural science, biological science and other interdisciplinary development has far -reaching scientific significance. The effects of plasma treatment on the biological properties and yield of green bean (Jiadouwang) were studied by using plasma seed processor and different dose (200mA~1600mA). The results showed that the plasma irradiation combined with alternating inductance was used to induce the physiological changes of the seeds.

The effects of physiological changes on the yield traits of the plants were investigated and analysed, such as stem coarse, branch number, first inflorescence node position, fruit number of inflorescences, single pod length, and seed disease resistance. The results showed that different current (dose) plasma treatment had different effects on the plant traits of green bean. The growth and development of green beans were obviously promoted by proper plasma treatment at different doses, especially the treatment current (dose) with a significant change in the effect on the plant traits of green bean was 1000mA, 1200mA and 1400mA (treatment groups were No. 5, 6, 7), respectively. The plasma treatment with different doses (plasma current 200mA~1600mA) can promote the growth, development and yield of green bean. The treatment yield effect of the appropriate dose (1000mA) is extremely significant. The plasma current treatment 600mA, 800mA, 1400mA has a significant effect on green bean yield. The trend prediction of single pod yield is basically consistent with the actual test data. the disease resistance of green beans after proper dose (600mA~1600mA) plasma treatment was better than that of untreated CK.

All in all, the effect of different doses of plasma treatment on the biological properties of green bean was different. The plant traits of green bean by proper plasma treatment were significantly improved compared with the control (CK), and the disease resistance of treated green bean was also better than that of untreated (CK). The yield of green bean in the eight treated groups could be improved by plasma treatment with different dosage.

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