

## Effects of Ozone Stress on Content of N and P in Soybean

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**Keywords:** Ozone; Nitrogen; Phosphorus; Soybean

**Abstract.** Objective: the effects of ozone concentration on the content of N and P in soybean. Methods: Taking Glycine max (L.) Mer. as an experimental material, the pot experiment was implemented in the open top chamber (OTC). The Three treatments with three replicates for each treatment were deployed: CK(atmospheric ozone concentration, 45 nmol/mol) and T1((80±10) nmol/mol) and T2((110±10) nmol/mol), it was sampled in the branching period, flowering and podding to determinate the content of N and P in soybean roots, stems and leaves at different times. Results: Compared to the CK, with the increasing of ozone concentration, (1) content of N was decreased ( $P < 0.05$ ) in leaves at podding, and it was increased in other organs at each stage ( $P < 0.05$ ); (2) content of P was decreased ( $P < 0.05$ ) in root at flowering and leaves at branching, and it was increased ( $P < 0.05$ ) first and then decreased at podding, other organs are increased ( $P < 0.05$ ) in each stage. Conclusion: the content of N and P in roots, stems and leaves of soybean were different at different ozone concentrations, provide experimental data and scientific guidance for the assessment of effects of O<sub>3</sub> stress on soybean.

### Introduction

With the gradual increase of industrial emissions and automobile exhaust gas pollution, ozone (O<sub>3</sub>) has become the main pollutants in the air near the ground, has been or will pose a serious threat to agricultural production [1,2,3]. In China, the concentration of O<sub>3</sub> in the environment increased by about 7% between 2005 and 2010, and it is estimated that by the year 2020, the amount of nitrogen oxides and oxygen oxides in our country will be three times that of 1990 [4,5,6]. Soybean is rich in nitrogen, phosphorus, potassium and other elements, which is of great significance in plant growth and metabolism. There are few studies on the variation of nitrogen and phosphorus absorption and utilization by crops under the condition of ozone stress, the conclusions are also different. Zheng et al. studies showed that the increase of ozone concentration increased the content of N elements in each component of rice [7]. Shao et al. studies showed that, compared with the control, the concentration of N and P in rice straw was significantly or significantly increased by ozone stress [8].

Soybean is one of the main crops in the northeast and is one of the most sensitive crops to O<sub>3</sub> pollution [9]. In recent years, a lot of researches on the effects of elevated O<sub>3</sub> on soybean have been carried out at home and abroad, but most of them focus on physiological characteristics and yield, and rarely involve the research on nutrient absorption and utilization of soybean under O<sub>3</sub> stress. In this study, "Tie Feng 29" soybean as material, the effects of O<sub>3</sub> concentration on content of N and P in soybean of root, stem and leaf were analyzed by using open top chamber (OTCs), provide experimental data and scientific guidance for the assessment of effects of O<sub>3</sub> stress on soybean.

### Materials and Methods

**Test Materials.** In this experiment, the cultivar "Tie feng 29" was used as a test material. The growth period of this variety is 130-133 days, and it is suitable for planting in soil with moderate or moderate fertility.

**Test Design.** The experiment was carried out in the Shenyang field ecological ecosystem station

of the Chinese Academy of Sciences, and the laboratory experiment was carried out in the Ecology Laboratory of Shenyang Agricultural University. Soybean was fumigated by open top chamber (OTC). The main equipment consists of six identical OTCs (regular octagonal cross section, side length 1.15m, height 2.4m, glass wall) and its associated ventilation and ventilation control equipment. Including the ozone generator (BGY-Q8, national science, North China), ozone sensor (S-900, AI Carlyle, New Zealand), temperature and humidity sensors and data analysis and automatic control of pneumatic system. During the whole test, the actual gas concentration in the gas chamber is controlled steadily.

The experiment consisted of 3 treatments: CK (control,  $O_3$  concentration in natural air, about 45nmol/mol), T1 ( $O_3$  concentration was  $(80 \pm 10)$  nmol/mol) and T2 ( $O_3$  concentration was  $(110 \pm 10)$  nmol/mol), repeated 3 times. Pot experiment was conducted on May 10, and about 120 plants ( $180,000$  plants/hm<sup>2</sup>) of each gas chamber were planted in the gas chamber on May 10.  $O_3$  was started on June 10 and fumigated for 8h (9: 00-17:00). During the test moisture, fertilizer uniform, no pests and weeds and other limiting factors. Samples were taken at the soybean branching stage (June 26), the flowering stage (July 18) and the podding stage (August 10), and ventilation was stopped until maturity on August 30. Two plants were randomly sampled for each treatment during each reproductive period, together with the underground stems and roots, and dug back to the laboratory for determination. The gas chambers were repeated three times.

**Measurement index and method.** Determination of dry matter: Drying and weighing

Determination of Nitrogen and Phosphorus in Plants: The content of N was determined by Kjeldahl method, and the content of P was determined by Molybdenum and Antimony Colorimetry.

**Experimental data processing.** Data was processed using Microsoft Excel 2010 software, the data are the mean  $\pm$  standard deviation of each treatment. One-way ANOVA was performed using SPSS17.0 software, and significance analysis was performed by least significant difference (LSD).

## Results and Analysis

### Effect of ozone concentration on content of N of soybean

**The content of N in the roots.** As can be seen from Fig. 1a, with the increasing of ozone concentration, compared with CK, except for the T1 treatment at flowering, the content of N increased ( $P < 0.01$ ) extremely significant in root. The content of N was increased firstly and then decreased at the branching stage. It was higher than CK for 34.06% ( $P < 0.01$ ) by CK, there was significant difference between the three treatments ( $P < 0.01$ ). It was firstly decreased and then increased in flowering, T2 treatment was the highest, which was 17.37% higher than CK treatment. It was increased gradually during the podding, it was significantly higher than that of CK treatment for 29.07% and 54.26% in T1 and T2 treatment. In addition, the content of N in root at podding stage was lower than the previous two periods.

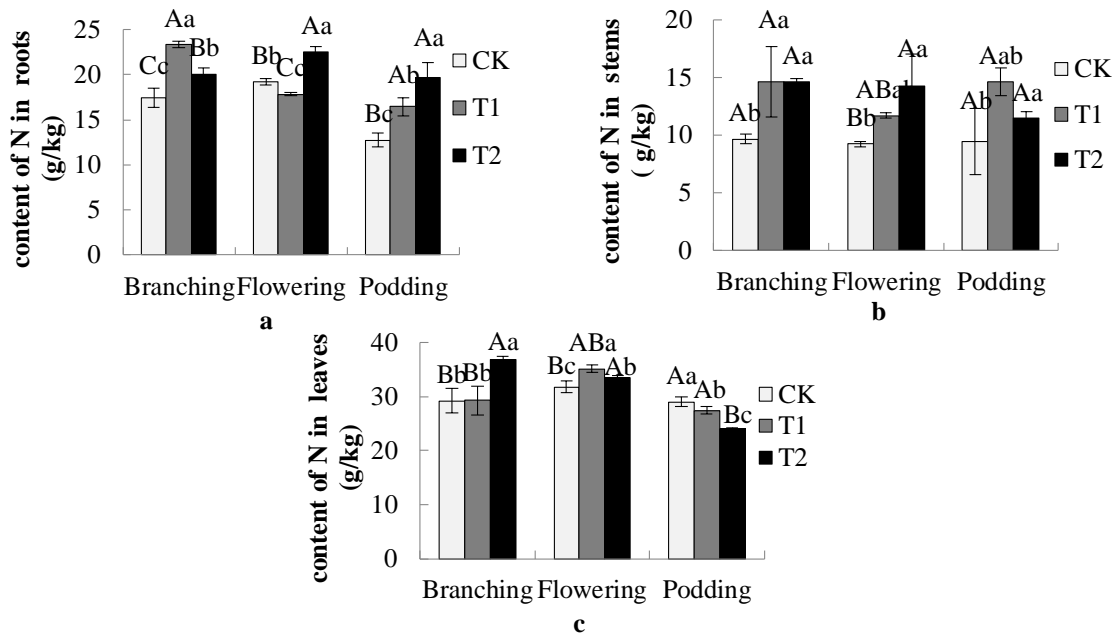


Figure 1. Content of N in soybean roots, stems and leaves under  $O_3$  stress

Note:  $n=3$ , different large and small letters in the figure respectively indicate that the difference between different treatments reaches 0.01 and 0.05 significance level, the same as below.

**The content of N in stems.** As can be seen from Fig. 1b, with the increasing of ozone concentration, compared with CK, the content of N was increased and then decreased, it was were significantly higher than that of CK ( $P < 0.05$ ) for 51.60% and 51.21% in T1 and T2 treatment at branching stage; at flowering stage, it showed a gradually increasing trend , it were higher than that of CK for 26.36% and 54.45% in T1 and T2 treatment; It was increased firstly and then decreased at podding, and significantly ( $P < 0.05$ ) higher than that of CK for 54.55% and 20.99% in T1 and T2 treatments.

**The content of N in leaves.** As can be seen from Fig. 1c, compared with CK, with the increasing of ozone concentration, the content of N increased gradually at the branching stage, The content of N in T2 treatment was significantly ( $P < 0.05$ ) higher than that in CK and T1 treatment for 25.96% and 25.86%; it was firstly increased and then decreased, it was the highest in T1 treatment and which was significantly higher than CK 10.47% ( $P < 0.05$ ), it was significantly higher than that of CK ( $P < 0.01$ ) 5.19% in T2 treatment at the flowering period; it was gradually decreased, the lowest was T2 which decreased significantly 20.52% ( $P < 0.01$ ) by CK at the podding stage.

#### Effect of ozone concentration on content of P of soybean

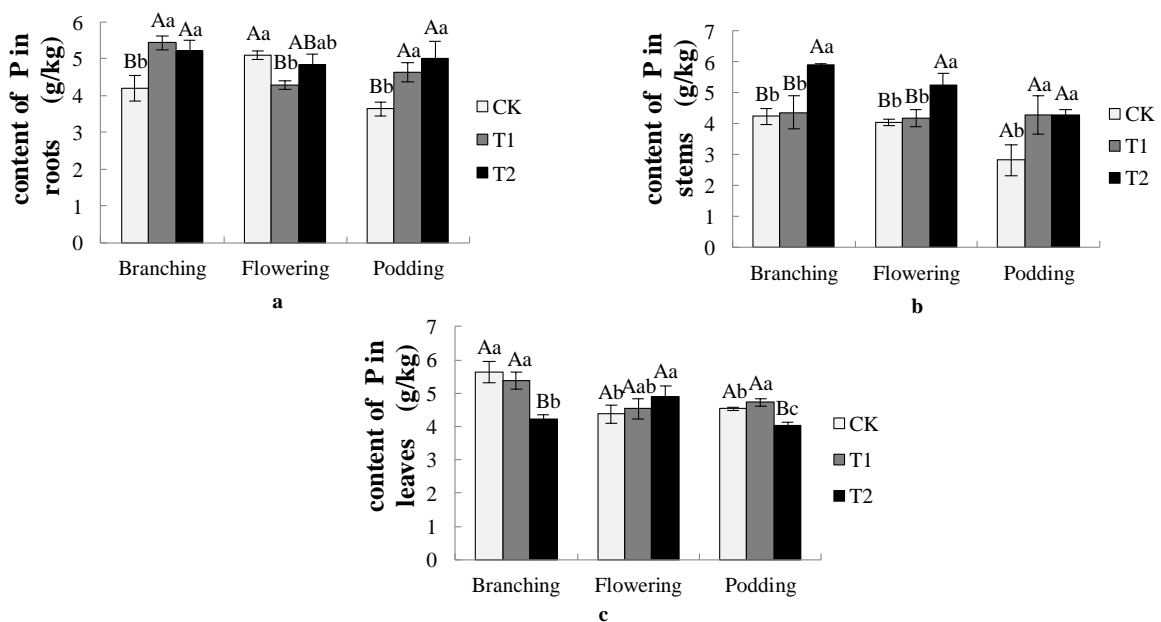


Figure 2. Content of P in soybean roots, stems and leaves under  $O_3$  stress

**The content of P in the roots.** As shown in Fig. 2a, compared with CK, with increasing of ozone concentration, the content of P increased firstly and then decreased in the roots at the branching stage, it was significantly higher than that of CK for 29.34% and 23.89% in T1 treatment and T2 treatment ( $P < 0.01$ ); it decreased first and then increased at the flowering stage, it was the highest in CK treatment, the lowest in T1 treatment which significantly lower than that of CK for 18.72% ( $P < 0.01$ ); it increased gradually at podding stage and significantly higher than that of CK for 27.19% and 37.96% in T1 treatment and T2 treatment ( $P < 0.01$ ).

**The content of P in stems.** As can be seen from Fig. 2b, with the increasing of ozone concentration, compared with the CK, at the branching stage, the content of P was higher than that of CK treatment for 2.95% and 39.18% in T1 treatment and T2 treatment; it was higher than that of CK treatment for 3.7% and 30.03% in T1 treatment and T2 treatment at the flowering stage; it was the highest in T1 treatment, the lowest in CK treatment, which was significantly higher than that of CK for 51.08% and 50.52% in T1 treatment and T2 treatment at podding stage ( $P < 0.01$ ).

**The content of P in leaves.** As shown in Fig. 2c, with the increasing of ozone concentration; compared with CK treatment, the content of P gradually decreased in leaves at the branching stage, it decreased significantly by 33.32% in T2 treatment ( $P < 0.01$ ) and decreased by 4.66% in T1 treatment by CK treatment; it increased gradually at the flowering stage, it was higher than that of CK treatment for 3.79% and 12.03% ( $P < 0.05$ ) in T1 treatment and T2 treatment; it increased first and then decreased, and it increased significantly by 4.34% in T1 treatment ( $P < 0.05$ ) and decreased by 12.75% in T2 treatment ( $P < 0.01$ ) by CK treatment at the podding stage.

## Conclusion and Discussion

The effects of increasing ozone concentration on the content of N and P have been reported in plants, but the results are not the same. Nitrogen is a necessary nutrient for plant growth, directly or indirectly, participates in and affects the growth and metabolism of plants, and it is necessary for cell division, expansion and growth [10]. This study shows that with the increase of ozone concentration, compared with CK, content of N was decreased ( $P < 0.05$ ) in leaves at podding, this may be because leaf is the organs of accumulating N before podding, and the nitrogen compounds will agglomerate into the grain, resulting in decreased. And it was increased in other organs at each stage ( $P < 0.05$ ), which indicated that root and stem of soybean had the ability to adapt under the ozone stress. However, the content of N decreased in leaf during the podding stage.

Phosphorus is a component of many organic compounds that are necessary for life-sustaining activities in the living body [10]. This study shows that, with the increase of ozone concentration, compared with CK, the content of P was decreased ( $P < 0.05$ ) in root at flowering and leaves at branching, and it was increased ( $P < 0.05$ ) first and then decreased at podding, other organs are increased ( $P < 0.05$ ) in each stage. P participates in a series of physiological processes in plants. Therefore, the increase of content of P may be an adaptive ability of soybean to adversity under ozone stress. During the period of branching and podding, it was decreased may be due to the transfer of P element mainly from the vegetative growth part to the grain after flowering. In summary, the content of N, P on soybean roots, stems and leaves have difference by the increase of ozone concentration in different periods.

## Acknowledgements

This study was supported by the National Natural Science Foundation of China (31570404).

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