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EFFECTS OF MATRINE ON PHOTOSYNTHESIS AND NITROGEN METABOLISM OF WHEAT UNDER NITROGEN DEFICIENCY CONDITION

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Abstract

Matrine is a natural compound that can effectively kill agricultural pests. However, whether Matrine can affect nitrogen utilization in wheat has not been reported. In this research, leaf spraying Matrine (100mg/L) was used to study the changes of photosynthetic pigment and nitrogen metabolic capacity at seedling stage of wheat leaves by the way of sand culture under the condition of nitrogen deficit. The results showed that exogenous Matrine decreased SOD and CAT activities in wheat leaves, but increased photosynthetic pigment content, nitrate reductase activity and nitrogen content in wheat leaves, thus ensuring wheat growth and development. The research can provide theoretical basis and technical support for Matrine to resist the combined damage of biological and abiotic stress in wheat cultivation.

Key words: Wheat, Matrine, Nitrogen deficiency, Photosynthesis.

Introduction

Wheat yield is influenced by both biological and abiotic factors. Nitrogen deficiency can not only affect the normal growth and development of wheat but also combine with other biological stresses to cause a considerable reduction in wheat yield. Therefore, how to effectively reduce this loss caused by biological stress under the condition of increasing nitrogen utilization of wheat, is one of the problems faced by agricultural production (Hura, 2020)

Matrine widely found in legumes such as Sophora flavescens, *Sophora alopecuroides* and *Radix sophorae* sub *prostrata*, is a natural plant pesticide (Huang *et al.*, 2016). It has broad-spectrum insecticidal and bactericidal effects, low toxicity to humans and animals, easy degradation, environmental safety, does not harm natural enemies (Ajaib *et al.*, 2021; Li, 2020), and is conducive to ecological balance, which makes it one of the few plant source pesticides with in-depth promotion value at present.

As an environmentally friendly pesticide, matrine can inhibit wheat *Gibberella zeae*, apple anthracnose (*Glomerella cingulata*), tomato *Botrytis cirerea*, It can also inhibit mycelia growth of wheat sheath blight, rice blast fungus and *Phytophthora capsici* by more than 80% (Danish *et al.*, 2024; Wu *et al.*, 2019; Zhang *et al.*, 2023). Studies have also shown that mung bean seeds soaked with 80 mg/L matrine have the best seed growth (Cao *et al.*, 2022). In addition, by adding matrine to the soil, SOD, POD and other enzyme activities of sweet tea roots can be increased, while matrine directly treated sweet tea seedlings can increase the net photosynthetic rate of leaves, thus promoting the accumulation of organic matter in the seedlings (Sun *et al*., 2010).

At present, there are no reports on whether matrine can directly affect plant nutrient utilization, but some studies have shown that matrine can promote the growth of cucumber cotyledon (Sun *et al.*, 2010) and enhance their stress resistance, the results of studies on the transport of alfalfa root nodles have also shown that matrine treatment with appropriate concentration can promote the migration and colonization of rhizobium from roots to stems and leaves. Thus, the nitrogen utilization capacity of alfalfa was improved (Miao *et al.*, 2018).

How to effectively reduce disease while improving the utilization of crop nutrients, so as to increase crop yield, is of great significance to ensure global food security. In view of the above problems, this study was the first to investigate the effect of matrine on nitrogen utilization in wheat, which will provide theoretical and technical support for its wide application in wheat cultivation.

Materials and Methods

Test materials and setup: The wheat tested in this study was Zheng Mai 1860, which was provided by the Wheat Institute of Henan Academy of Agricultural Sciences. Matrine, molecular formula $C_{15}H_{24}N_2O$, supplied by Solebol Corporation. Homogeneous wheat seeds were selected of disinfected, germinated, and transplanted into POTS with quartz sand as the substrate for planting. During wheat growth, irrigation was carried out with nitrogen free Hoagland nutrient solution. When the wheat grew to two leaves, with water as the control (CK), 100mg/L matrine solution (KS) was sprayed on the leaf surface, and the leaves and stems were evenly covered with a layer of water film. Each treatment was repeated 4 times. The relevant indexes were measured at 24h, 48h and 72h. The seedlings were fed with Hoagland nutrient solution by sand culture, with temperatures of 22 and 25℃, 12/12h day/night and light of 2000 lux.

Test indicators and methods: Chlorophyll fluorescence determination. A hand-held SPAD meter was used to determine the chlorophyll fluorescence of four POTS. The chlorophyll fluorescence values of each leaf were measured by 3 values from the front to the back, and their average values were used to represent the chlorophyll fluorescence values of the leaves. After that, the mean value and error degree of the four repetitions were calculated respectively, and the significance analysis was carried out (Liu *et al*., 2007).

Fluorescence determination of nitrogen content: A hand-held N-PEN meter was used to measure the chlorophyll fluorescence of four POTS. The chlorophyll fluorescence values of each leaf were measured by 3 values from the front to the back, and their average values were

used to represent the chlorophyll fluorescence values of the leaves. After that, the mean value and error degree of the four repetitions were calculated respectively, and the significance analysis was carried out (Sharma *et al.*, 2021).

Determination of antioxidant activity: SOD value of leaves was determined by nitrogen blue tetrazole method, POD value was determined by guaiacol method and CAT value was determined by hydrogen peroxide method. Each treatment was repeated 4 times (Chen *et al.*, 2015).

Determination of nitrate reductase. The nitrate reductase activity of leaves was determined by nitric acid reduction method. Each treatment was repeated 4 times (Wang *et al.*, 2003)

Statistical analysis: Excel and SPSS were used for data statistics and analysis, and the difference was significant ($P < 0.05$).

Results

Changes in pigment content: Photosynthetic pigment is the basic structure of plant photosynthesis, and its content in leaves directly affects the photosynthetic efficiency of plants. As shown in Fig. 1, SPAD value of KS was higher than CK at 24h and 48h after treatment, but contrary to that at 72h, there was no significant difference between treatments. The results showed that under the condition of nitrogen deficiency, spraying matrine on wheat leaves at seedling stage could effectively increase the photosynthetic pigment content in leaves within 48h.

Change of nitrogen content: As shown in Fig. 2, at 24h, 48h and 72h, nitrogen content at different treatments was first decreased and then increased, among which nitrogen content at KS treatment was higher than CK treatment, but there was no significant difference among all the treatments. The results showed that matrine spraying could effectively increase the nitrogen content of wheat leaves at the seedling stage.

Changes in antioxidant capacity of membrane lipids: SOD, POD and CAT are three antioxidant enzymes that can effectively remove oxides and maintain cell stability in plants, and their activity directly affects the change of plant stress resistance. As shown in Fig. 3, SOD and CAT activities of KS were lower than CK at 72h, and CAT activities were significantly different. On the contrary, the POD activity of KS was higher than CK, but the difference was not obvious. The results showed that matrine treatment could change the antioxidant activity of leaves at 72h, but there were differences among different antioxidant enzymes.

Changes in nitrogen use efficiency: As shown in Fig. 4, the nitrate reductase activity of CK and KS was higher at 48h, but lower at 24h and 72h. Compared with CK, the nitrate reductase activity of KS treatment at different time periods was higher, but there was no difference between CK and KS. The results showed that exogenous matrine could increase the nitrate reductase activity in wheat leaves at the seedling stage.

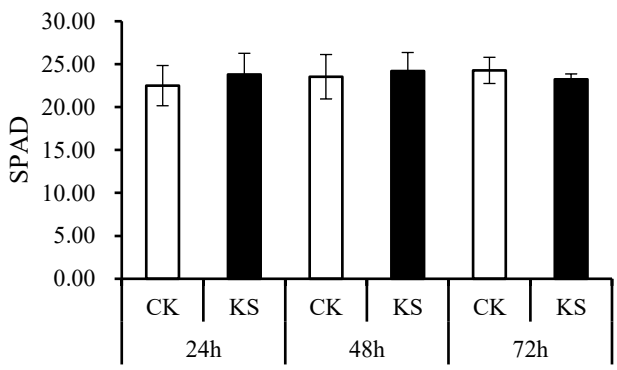

Fig. 1. Changes of chlorophyll content in wheat leaves at different times.

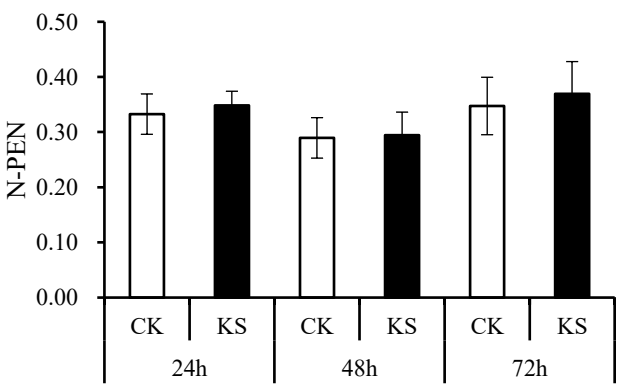

Fig. 2. Changes of nitrogen content in wheat leaves at different times.

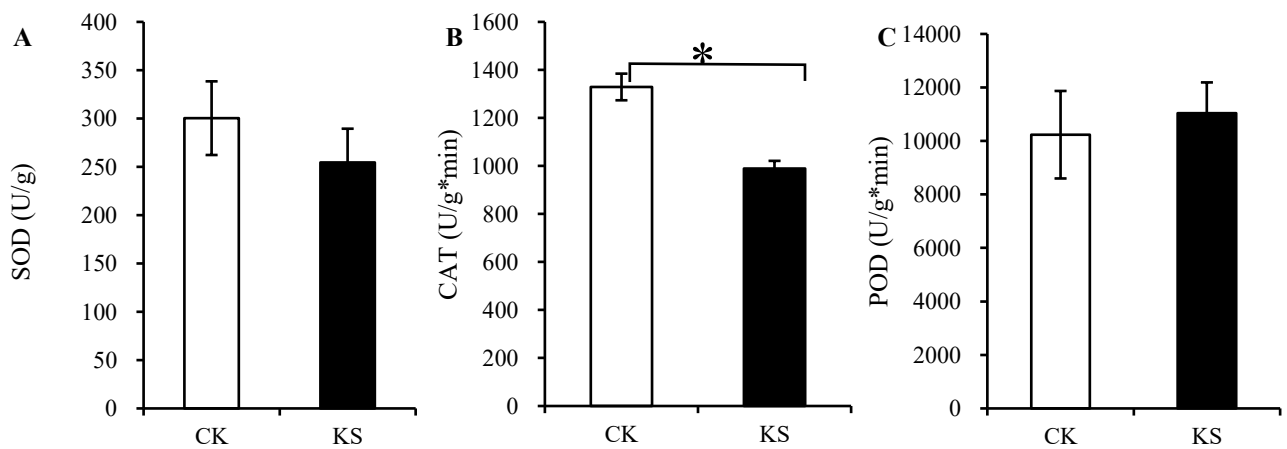

Fig. 3. Antioxidant activity of leaves at 72h.

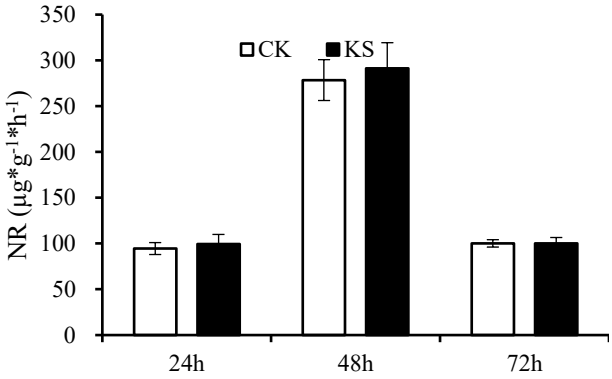

Fig. 4. Changes of nitrate reductase activity in wheat leaves at different time periods.

Discussion

Plants can fix light energy through photosynthesis and synthesize organic matter, so as to ensure their own growth and development. The photosynthetic pigment content of leaves directly affects the level of plant photosynthesis, and in modern agricultural production, high light efficiency is the basis of crop quality and high yield. In this study, under the condition of nitrogen deficiency, the photosynthetic pigment content of two-leaf single-stage wheat was increased within 72h after spraying water on the leaf surface. Matrine spray treatment was higher in 48h, but lower in 72h than the control, but the difference among different treatments was not obvious, so there was a certain error in 72h treatment. Similar to this study, after treating alfalfa seedling roots with different concentrations of matrine, chlorophyll content, growth rate, root length and nitrogen content of seedling leaves were significantly improved (Miao *et al.*, 2018). Therefore, spraying 100mg/L matrine on the leaf surface can effectively increase the content of photosynthetic pigment in wheat and enhance the photosynthesis of wheat at seedling stage.

On the other hand, although no research report has been found on the direct effect of exogenous matrine on plant nitrogen metabolism and utilization, in this study, the nitrate reductase activity of clean water and matrine treatment was highly consistent with the trend of nitrogen fluorescence, and the nitrate reductase activity and nitrogen content of wheat leaves treated with matrine were higher than those treated with clean water. Therefore, it is speculated that matrine can reduce the degradation of nitrogen-containing substances and improve the nitrogen utilization level of leaves by increasing the activity of nitrogen metabolizing enzymes.

As a plant-derived antibacterial insecticide, matrine can effectively kill different bacteria and pests, which has been widely reported. Therefore, matrine can break the balance of animal cell regulatory system and destroy cell homeostasis, resulting in the death of fungi and insects. Similarly, in this study, matrine treatment decreased SOD and CAT antioxidant activity, but POD activity was increased. Therefore, it is speculated that exogenous matrine can also reduce the antioxidant scavenging ability of plants, but plants still have some additional peroxide scavenging mechanisms, and their resistance to matrine is strong, which effectively ensures the normal growth and development of plants when matrine is used as a pesticide to remove pests.

In summary, the results of this study showed that foliar spraying of 100mg/L matrine could effectively enhance the photosynthesis of wheat and improve the nitrogen utilization capacity, but its molecular mechanism needs to be further explored.

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