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Effect of nitrogen on photosynthetic pigments of relay strip intercropping soybean under drought stress

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Abstract: A pot experiment was designed under drought stress condition to study the effect of different nitrogen levels on photosynthetic pigments in the leaves of relay strip intercropping soybean. The Chla, Chlb, were measured, Chl content, Chla/b was calculated. The result showed that effects of nitrogen and drought stress on Chla were not as big as that of Chlb. When severe drought happened, Chla content reduced significantly, mild and moderate drought stress did not decrease Chla content significantly. With N supply, mild and moderate drought enhanced Chlb content and Chl content, but Chlb content and Chl content decreased significantly when drought happened without N supply. Appropriate N supply is recommended to improve photosynthetic pigments efficiency under drought stress.

Introduction

As a result of population increases, the demand for food is also constantly increasing [1, 2]. Multiple cropping systems using intercropping can produce a greater yield on a given piece of land by maximizing resources [3]. In China half of the total grain yield is produced by multiple cropping [4]. Affected by climate and hilly landforms, soybeans under the wheat-corn/soybean relay strip intercropping system are typically exposed to drought stress in southwest China. Nitrogen for crop drought resistance has double role in water deficit [5]. N supply could improve photosynthetic capacity by increasing leaf area and photosynthetic pigment contents, and enhancing photosynthetic efficiency under water deficit [6]. Therefore, under drought stress condition, pot experiment was conducted to study the effects of nitrogen on Chla, Chlb, Chl and Chla/b of relay intercropping soybean, and to provide an identification system for the study of soybean drought resistance, to provide theoretical basis and technical support in the application of nitrogen for soybeans.

Materials and Methods

Materials. Soybean cultivar Gongxuan No.1, a major component of southwestern soybean cultivars, was tested in the experiments.

Experimental Design. The experiment was conducted in a relay strip intercropping system at the farm of Sichuan Agricultural University. Soybean seeds were sown in the pots. Urea was dissolved in water for base fertilizer, and the tray in the pelvic floor was used to avoid the leaching of nitrogen after the rain. Only three plants were allowed to grow per pot. Each treatment was conducted with three replicates, and each replicate had 6 pots. Four nitrogen treatments were used 0 g N pot^{-1}, 0.35

g N pot^{-1}, 0.70 g N pot^{-1}, 1.40 g N pot^{-1}, which were equivalent to 0 kgN·ha^{-1}(N_1),45 kgN·ha^{-1}(N_2),90 kgN·ha^{-1}(N_3),180 kgN·ha^{-1}(N_4). Four drought stress treatments were imposed after the pots were moved in the shed, at the branching stage of soybean. 1/4 of the pots were kept continuously moist (WW, 75±2% of the field water capacity, short for FWC), and so did the light drought (LD, 60±2% of the field water capacity) and moderate drought (MD, 45±2% of the field water capacity) and severe drought (SD, 30±2% of the field water capacity). Soybean pots were placed under shade of maize to simulate light environment of the relay strip intercropping system of wheat-corn-soybean. Pots were moved into a shed with shading net at branching stage. The light under the net was 65% of environmental light. Net was moved, when maize in the field matured. The characters were determined 7 days after drought stress.

Statistic analyses. Results were analyzed by two-way analysis of variance (LSD) and means were compared by Duncan's multiple range tests at $P<0.05$. All data were organized in Excel (Microsoft) spread sheets and processed by the software Statistical Package for the Social Sciences (SPSS) version 11.5.

Results and Discussion

Chl a. From Table 1, it was found that drought stress significantly decreased the content of Chla, and the Chla content was lower as the degree of drought stress became severely. Under the same nitrogen treatment, the content of Chla was the highest at control (75% of FWC), followed by mild stress (60% of FWC), moderate stress (45% of FWC) and severe stress (30% of FWC). The content of Chla was the lowest at 0.42 mg•g^{-1} DW at the treatment of 0 g N pot^{-1} under 30% of FWC, and the content of Chla was the highest at 1.97 mg•g^{-1} DW under treatment of 0, 0.70 and 1.4 g N pot^{-1} under 75% of FWC, under treatment of 0 g N pot^{-1}of 60% of FWC. Under the same water supply, Chla content was higher as the N application increased.

Table 1 Effect of drought stress and nitrogen levels on Chla content (mg•g^{-1} DW)

Treatment	0 g N pot^{-1}	0.35 g N pot^{-1}	0.70 g N pot^{-1}	1.40 g N pot^{-1}
30% of FWC	0.42c	1.39b	1.89a	1.80a
45% of FWC	1.81a	1.81a	1.89a	1.85a
60% of FWC	1.97a	1.95a	1.95a	1.95a
75% of FWC	1.97a	1.96a	1.97a	1.97a

Note: The same small letters indicate the significant differences at $P<0.05$, the same below.

Chl b. From Table 2, it was found that appropriate N supply could increase Chlb content under drought stress. With zero N supply, Chlb content reduced significantly as the water supply decreased. Under zero N supply, the Chl b content was lowest at 0.18 mg•g^{-1} DW at the treatment of 30% of FWC, which was 14.06% of 75% of FWC. Under treatment of 75% of FWC, N supply decreased Chlb content, but the differences were not significant. Under 45% and 60% of FWC, appropriate N supply could increase Chlb content. Under 0 g N pot^{-1} **,** Chlb content was the highest at 75% of FWC, followed by mild stress, and then moderate stress, severe stress. Under 0.35 g N pot^{-1}**,** Chlb content was the highest at mild stress, followed by moderate stress, and then control, severe stress. Under 0.7 g N pot^{-1}**,** Chlb content was the highest at moderate stress, followed by mild stress, and then control, severe stress. Under 1.4 g N pot^{-1}**,** Chlb content was the highest at moderate stress, followed by mild stress, and then control, severe stress.

Table 2 Effect of drought stress and nitrogen levels on Chlb content (mg•g^{-1} DW)

Treatment	0 g N pot^{-1}	0.35 g N pot^{-1}	0.70 g N pot^{-1}	1.40 g N pot^{-1}
30% of FWC	0.18g	0.67f	1.04bcde	0.88e
45% of FWC	0.94de	1.22abc	1.34a	1.03cde
60% of FWC	1.26ab	1.23abc	1.32a	1.01cde
75% of FWC	1.28a	1.13abcd	0.99de	0.91de

Chl. From Table 3, it was found that appropriate N supply could increase Chl content under drought stress. With zero N supply, Chl content reduced significantly as the water supply decreased. Under zero N supply, the Chl content was lowest at 0.6 mg•g^{-1} DW at the treatment of 30% of FWC, which was 18.46% of 75% of FWC. Under treatment of 75% of FWC, N supply decreased Chl content, but the differences were not significant. Under 30%, 45% and 60% of FWC, appropriate N supply could increase Chl content. Under 0 g N pot^{-1}, Chl content was the highest at 75% of FWC, followed by mild stress, and then moderate stress, severe stress. Under 0.35 g N pot^{-1}, Chl content was the highest at mild stress, followed by control, and then moderate stress, severe stress. Under 0.7 g N pot^{-1}, Chl content was the highest at mild stress, followed by moderate stress, and then control, severe stress. Under 1.4 g N pot^{-1}, Chl content was the highest at mild stress, followed by moderate stress, control, and then severe stress.

Table 3 Effect of drought stress and nitrogen levels on Chl content (mg•g^{-1} DW)

Treatment	0 g N pot^{-1}	0.35 g N pot^{-1}	0.70 g N pot^{-1}	1.40 g N pot^{-1}
30% of FWC	0.6f	2.06e	2.93bc	2.68d
45% of FWC	2.75d	3.03bc	3.23ab	2.88cd
60% of FWC	3.23ab	3.18ab	3.27a	2.96bc
75% of FWC	3.25a	3.09bc	2.96bc	2.88cd

Chl a/b. From Table 4, it was found that appropriate N supply could increase Chl a/b under drought stress. With zero N supply, Chl a/b enhanced significantly as the water supply decreased. Under zero N supply, the Chl a/b was highest at 2.33 at the treatment of 30% of FWC, which was 151.30% of 75% of FWC. Under treatment of 75% of FWC, N supply significantly increased Chl a/b. Under 30%, 45% and 60% of FWC, appropriate N supply could increase Chl a/b. Under 0 g N pot^{-1}, Chl a/b was the highest at severe stress, followed by moderate stress, and then mild stress, control. Under 0.35 g N pot^{-1}, Chl a/b was the highest at severe stress, followed by control , and then mild stress, moderate stress,. Under 0.7 g N pot^{-1}, Chl a/b was the highest at control, followed by severe stress, and then mild stress, moderate stress. Under 1.4 g N pot^{-1}, Chl a/b was the highest at control, followed by severe stress and then mild stress , moderate stress.

Table 4 Effect of drought stress and nitrogen levels on Chla/b content

Treatment	0 g N pot^{-1}	0.35 g N pot^{-1}	0.70 g N pot^{-1}	1.40 g N pot^{-1}
30% of FWC	2.33a	2.07b	1.82c	2.05b
45% of FWC	1.93b	1.48e	1.41e	1.8c
60% of FWC	1.56d	1.59d	1.48e	1.93b
75% of FWC	1.54d	1.73cd	1.99b	2.16ab

Conclusion

Chlorophyll is the photosynthetic pigment of plants. Chlorophyll content can serve as a measure for the plant's ability to use light, as chlorophyll plays a central role in the absorption and transmission of light quantum. Absorption spectra of Chl a and Chl b are similar, but the absorption peaks in the red light is higher in Chl a, and the absorption peaks in blue light are higher in Chl b [7, 8]. Therefore, the relative increase of Chl b (or decrease of Chl a/b ratio) enables plants to improve efficiency of blue-violet light absorption, and adapt to a shaded environment. Studies show that chlorophyll content of shade-tolerant plants increases under shade. Çiçek and Çakırlar[9], reported that salt stress affects the Chl a/b ratio in several soybean cultivars. Some of the cultivars seemed to adapt to the salt stress by reducing their Chl a/b ratio, which suggests that those cultivars may have a larger antenna size. The results of this study showed that when drought stress happened, Chla content reduced, Chlb and Chl content increased under the treatment of which with N supply. But Chlb and Chl content decreased when drought happened and when there were no N supply. So, appropriate N supply could affect soybean Chlb, Chlb, Chl content and Chl a/b ratio to adapt to drought stress.

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