Effects of Seed Treatment with Uniconazole Powder on Soybean Morphological Characteristics and Yield under Drought Stress

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Keywords: Soybean; Drought stress; Seed treatment with uniconazole powder; Morphological characteristics; Yield

Abstract: The flowering stage is the key yield determinant period of soybean. Short-duration water stress occurring during this stage significantly reduced soybean development and final productivity. Seed treatment with uniconazole powder application plays an important role in alleviating the adverse effects of dry soil on plant development. In order to explore effects of uniconazole on soybean morphological characteristics and yield under drought stress, different rate of uniconazole powder were examined under developing gradually drought stress during flowering stage. The yield of soybean decreased under drought, uniconazole application increased yield. All results suggest that 4 mg/kg is the optimal uniconazole application rate under drought for soybean at the flowering stage.

Introduction

Soybean originated in China, is the major grain and oil crops in China. In recent years, with the improvement of people's living standards and aquaculture development, China's soybean supply is in short supply, the development of soybean production is acute [1]. The soybean production and development are restricted by low comparative benefit in Northern China. Meanwhile, as a typical arid agricultural area, Southwest region of China is abundant in heat resource, so it is suitable to develop relay cropping soybean and the potential area is great [2-3]. Affected by climate and hilly landforms, the frequency of summer drought in southwest China is high. But soybean is the most sensitive crop to water shortage in legume crops, the water requirement is high and the root system is not huge [4]. The research results showed that the drought stress reduced the photosynthetic rate, stomatal conductance and transpiration rate, the yield loss was up to 46% under the drought stress [5-8]. Various cultivation measures and physiological control measures are used to reduce the negative effects of drought stress on plant growth, plant growth regulators are one of them. Such as exogenous 6-BA, paclobutrazol, uniconazole can improve plant drought resistance. Many studies have shown that uniconazole has the effect of delaying senescence and increasing crop yield [9, 10]. Therefore, under drought stress condition, pot experiment was conducted to study the effects of seed treatment with uniconazole powder on morphological characteristics and yield of 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 soybeans.

Materials and Methods

Materials. Soybean cultivar Gongxuan No.1, a major component of southwestern soybean cultivars, was tested in the experiments. Uniconazole is a 5% wettable powder produced by Sichuan LanYan Co., Ltd.

Experimental Design. The experiment was conducted in a relay strip intercropping system at the farm of

Sichuan Agricultural University. Soybean seeds treated with uniconazole powder then were sown in the pots. The rate of uniconazole powder was A_0, 0; A_1, 2; A_2, 4 and A_3, 8 mg/kg seeds. Only three plants were allowed to grow per pot. Fertilizer containing 30 kg N/ha, 60 kg P_2O_5/ha and 60 kg K_2O/ha was thoroughly mixed in the soil of each pot. Each treatment was conducted with three replicates, and each replicate had 30 pots. Soil moisture in pots was kept at 75% of soil field capacity by manual watering until the drought stress treatments were initiated. Soybean pots were placed in one row in each strip where the wheat was grown with 30 cm hole spacing after wheat harvest to simulate light environment of the relay strip intercropping system of wheat-corn-soybean. Pots were moved into a shed with a shading net (Yaan Nongzhi CO., China) at blooming stage. The light under the net was 65% of environmental light. Net was moved, when maize in the field matured. Four drought stress treatments were imposed after the pots were moved in the shed, 80 days after sowing. 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). Withhold drought stress for seven days, and rewatered the plants to gain seed yield. Measure fresh soil weight through three points in 0-20 cm in each pot and steady dry weight after several hours in an oven at 70 ^{0}C with ethanol. Calculate the amount of lost water through the soil field capacity, and then add corresponding water to maintain soil moisture at the desired level. The parameters were all measured on day 7 after initiating water 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

Plant height. We can see from Table 1, water deficit stress decreased plant height, but the differences were not significant. Uniconazole significantly reduced the plant height of soybean. Under the same FWC (field water capacity), the plant height reduced as the concentration increased. When the FWC was 75%, the soybean plant height of 8 mg kg^{-1} uniconazole treatment was 48.6% of that of control. When the FWC was 60%, the soybean plant height of 8 mg kg^{-1} uniconazole treatment was 50.9% of that of control. When the FWC was 45%, the soybean plant height of 8 mg kg^{-1} uniconazole treatment was 50.6% of that of control. When the FWC was 30%, the soybean plant height of 8 mg kg^{-1} uniconazole treatment was 47.1% of that of control.

Table 1 Effects of uniconazole on plant height of soybean under drought stress (cm)

Treatments	0 mg kg^{-1}	2 mg kg^{-1}	4 mg kg^{-1}	8 mg kg^{-1}
30% of FWC	79.9 b	49.6 cdef	44.6 ef	37.6 f
45% of FWC	84.5 ab	53.8 cde	45.44 def	42.8 ef
60% of FWC	86.2 ab	57.8 cd	48.7 def	43.9 ef
75% of FWC	93.2 a	61.6 c	49.6 cdef	45.3 def

Within columns, means followed by the same small and capital letters are not significantly different at the 0.05 level of probability by Duncan's multiple range test. FWC represents field water capacity; 0, 2, 4, 8 mg kg^{-1} represent the concentrations of dry seed treatment with uniconazole, the same below.

Stem diameter. We can see from Table 2, water deficit stress decreased stem diameter, but the differences were not significant. Uniconazole significantly increased the stem diameter, the diameter of 4 mg kg^{-1} treatment was highest as it compared to the other uniconazole treatments. Under the same FWC, The general tend was first increased then decreased. When the FWC was 75%, the soybean plant height of 4 mg kg^{-1} uniconazole treatment was 166.4% of that of control. When the FWC was 60%, the soybean plant height of 4 mg kg^{-1} uniconazole treatment was 163.6% of that of control. When the FWC was 45%, the soybean plant height of 4 mg kg^{-1} uniconazole treatment was 174.7% of that of control. When the FWC was 30%, the soybean plant height of 4 mg kg^{-1} uniconazole treatment was 149.4% of that of control.

Table 2 Effects of uniconazole on stem diameter of soybean under drought stress (cm)

Treatments	0 mg kg^{-1}	2 mg kg^{-1}	4 mg kg^{-1}	8 mg kg^{-1}
30% of FWC	4.84d	6.74c	7.23ab	6.43c
45% of FWC	4.43d	6.8c	7.74a	6.75c
60% of FWC	4.65d	7.03b	7.61a	7.25ab
75% of FWC	4.47d	7.15ab	7.44a	7.28ab

SPAD value. We can see from Table 3, uniconazole significantly increased the SPAD value soybean leaf. Water deficit did not significantly influence SPAD value due to short duration of water deficit perhaps. When the FWC was 75%, the soybean SPAD value of 4 mg kg^{-1} uniconazole treatment was 106.8% of that of control. When the FWC was 60%, the soybean SPAD value of 4 mg kg^{-1} uniconazole treatment was 110.2% of that of control. When the FWC was 45%, the soybean SPAD value of 4 mg kg^{-1} uniconazole treatment was 108.4% of that of control. When the FWC was 30%, the soybean SPAD value of 4 mg kg^{-1} uniconazole treatment was 108.9% of that of control.

Table 3 Effects of uniconazole on SPAD value of soybean under drought stress

Treatments	0 mg kg^{-1}	2 mg kg^{-1}	4 mg kg^{-1}	8 mg kg^{-1}
30% of FWC	36.93b	38.2ab	40.23a	36.8b
45% of FWC	36.27bc	37.17b	39.33a	38.10ab
60% of FWC	35.83c	36.83b	39.5a	39.53a
75% of FWC	36.17bc	37.67b	38.63ab	36.73b

Branch number. We can see from Table 4, mild water deficit stress increased branch number of soybean, moderate drought and severe drought decreased branch number. uniconazole significantly increased the branch number of soybean.

Table 4 Effects of uniconazole on branch number of soybean under drought stress

Treatments	0 mg kg^{-1}	2 mg kg^{-1}	4 mg kg^{-1}	8 mg kg^{-1}
30% of FWC	4.3d	4.7c	5.7ab	5.4ab
45% of FWC	4.7c	5.0b	6.0a	5.3ab
60% of FWC	5.3ab	5.0b	6.3a	6.3a
75% of FWC	3.0e	4.7c	5.0b	6.0a

Node number of main stem. We can see from Table 5, water deficit stress significantly decreased node number of soybean main stem. Uniconazole significantly increased node number, 4 mg kg^{-1} uniconazole treatment had the most node number.

Table 5 Effects of uniconazole on node number of soybean main stem under drought stress

Treatments	0 mg kg-1	2 mg kg-1	4 mg kg-1	8 mg kg-1
30% of FWC	8.3e	13.7bc	13.9bc	13.0c
45% of FWC	10.7d	14.0b	14.0b	13.7bc
60% of FWC	11.0d	14.0b	14.3b	14.0b
75% of FWC	11.3d	16.3a	14.0b	14.3b

Yield. We can see from Table 6, water deficit stress decreased soybean seed yield per pot, the differences were significant. Uniconazole significantly increased soybean seed yield per pot. Under the same FWC , the yield increased as the concentration increased, and then decreased when the concentration of uniconazole reached 8 mg kg^{-1}.

Table 6 Effects of uniconazole on yield of soybean under drought stress (g pot^{-1})

Treatments	0 mg kg-1	2 mg kg-1	4 mg kg-1	8 mg kg-1
30% of FWC	10.74e	11.02e	11.78de	11.66de
45% of FWC	12.24d	12.32d	13.17cd	12.62d
60% of FWC	13.99cd	14.07c	14.39c	14.30c
75% of FWC	15.73b	16.16b	19.08a	16.90b

Conclusion

Drought is a major abiotic factor that limits agricultural crop production. To improve agricultural productivity within limited land and water resources, it is imperative to ensure high crop yields against unfavorable environmental stresses. There is an optimum plant height for maximum photosynthetic capacity within a vegetation canopy, and reducing plant height below this level may reduce crop yields. In the study, plant height was seriously shortened by 8 mg kg^{-1} uniconazole treatment. Uniconazole with a relatively low concentration of 4 mg kg^{-1}, as in this experiment, was required for improvement of plant growth under stress conditions though a better morphological characteristics and yield.

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