Effects of Soil Water Stress on Module Biomass Allocation in Xinjiang Large-Leaf Alfalfa: Postprint

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Abstract

Using Xinjiang large-leaf alfalfa as experimental material, a pot experiment was conducted to elucidate changes in component biomass of Xinjiang large-leaf alfalfa under different soil water stress treatments (85%, 65%, and 45% of field capacity). The results showed that: (1) Under mild water stress, Xinjiang large-leaf alfalfa exhibited the highest dry weight biomass, longest taproot, and maximum numbers of branches and leaves; (2) Fine root number, dry weight biomass, component proportion, and growth rate all followed the pattern of severe water stress > mild water stress > full irrigation; (3) Different soil water stress treatments resulted in distinct patterns of biomass allocation proportions among components. Under full irrigation and mild water stress, the pattern was: stem component > leaf component > root component > flower component, whereas under severe water stress, the pattern was: root component > stem component > leaf component > flower component; (4) Under mild water stress, the root-to-shoot ratio and belowground-to-aboveground ratio were optimal, with plants adapting to arid environments and growing robustly. These results provide a scientific basis for revealing efficient water use mechanisms in crops and theoretical support for increasing yield of Xinjiang large-leaf alfalfa in arid and semi-arid regions.

Full Text

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Effects of Soil Moisture Stress on Biomass Allocation of Medicago sativa cv. Xinjiangdaye

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Abstract

In this study, Medicago sativa cv. Xinjiangdaye was used as experimental material in a pot culture experiment to investigate changes in component biomass under different soil moisture stresses (field capacities of 85%, 65%, and 45%). The results showed: (1) Under slight water stress, dry weight biomass, taproot length, branch number, and leaf number of Medicago sativa cv. Xinjiangdaye reached their highest values; (2) The number, dry weight biomass, proportion, and growth rate of fine roots followed the order: severe water stress > slight water stress > full water supply; (3) Biomass allocation proportions differed among water treatments. Under full water supply and slight water stress, the order was stem > leaf > root > flower components, while under severe water stress, the order shifted to root > stem > leaf > flower components; (4) Under slight water stress, both the rhizome ratio and the root-to-shoot ratio were optimal, indicating healthy plant adaptation to dry environments. These findings provide a scientific basis for understanding efficient water use mechanisms in crops and offer theoretical support for improving yields of Medicago sativa cv. Xinjiangdaye in arid and semiarid regions.

Keywords: Medicago sativa cv. Xinjiangdaye; soil water stress; component; biomass allocation

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1. Materials and Methods

1.1 Experimental Design

In 2018, a pot culture experiment was conducted at the College of Forestry, Gansu Agricultural University. Medicago sativa cv. Xinjiangdaye served as the experimental material. Three water treatments were established at 85% (TA), 65% (TB), and 45% (TC) of field capacity to examine effects of different soil moisture stresses on biomass components. The experimental site had an average annual temperature of 10.8°C, 2446 hours of sunshine, and a frost-free period of 180 days.

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2. Results

2.2 Fine Root Response

[Figure 2: see original paper] illustrates the effects of soil moisture stress on fine roots of Medicago sativa cv. Xinjiangdaye. Fine root number, dry weight biomass, proportion, and growth rate followed the order: TC (severe stress) > TB (moderate stress) > TA (full supply), with statistically significant differences between treatments ($P < 0.05$). This demonstrates that severe water stress stimulates fine root proliferation as an adaptive mechanism.

2.4 Biomass Allocation Patterns

[Figure 3: see original paper] shows biomass allocation across treatments. Under full water supply (TA) and slight water stress (TB), allocation priority was: stem component > leaf component > root component > flower component. However, under severe water stress (TC), the pattern shifted to: root component > stem component > leaf component > flower component. These differences were statistically significant ($P < 0.05$), indicating a fundamental change in plant resource allocation strategy under severe water limitation.

Table 1 presents detailed measurements of component biomass across treatments. Values represent means ± standard deviation. Different letters indicate significant differences at $P < 0.05$.

Treatment	Root Length (cm)	Stem Biomass (g)	Leaf Biomass (g)	Flower Biomass (g)
TA (85%)	13.09±4.41a	45.17±26.47b	22.67±7.89a	16.25±9.19b
TB (65%)	14.18±5.64a	84.50±26.47a	23.33±4.50a	19.42±12.57b
TC (45%)	11.33±4.32a	37.67±26.47b	25.00±8.12a	32.00±10.21a

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3. Discussion

3.1 Adaptive Strategies to Water Stress

Soil moisture stress significantly influences alfalfa growth and biomass allocation patterns. Under slight water stress (TB), plants achieved optimal growth with maximal values for dry weight biomass, taproot length, branch number, and leaf number. The rhizome ratio and root-to-shoot ratio were also optimal under TB treatment, indicating that moderate water stress promotes balanced growth and adaptation to dry environments.

Under severe water stress (TC), alfalfa exhibited a clear stress-response strategy by prioritizing root development. The shift in biomass allocation toward root components (root > stem > leaf > flower) represents a survival mechanism that enhances water acquisition capacity. This is further supported by the significant increase in fine root number and biomass under TC conditions.

The study demonstrates that Medicago sativa cv. Xinjiangdaye possesses flexible allocation strategies that vary with water availability. These results provide crucial insights for optimizing irrigation management in arid and semiarid regions, suggesting that moderate water stress (65% field capacity) may represent an optimal balance between growth maintenance and water use efficiency. The findings offer both a scientific basis for understanding crop water use mechanisms and practical guidance for improving alfalfa yields under water-limited conditions.

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Note: Figure translations are in progress. See original paper for figures.