干旱胁迫对大豆根系发育影响初报

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摘 要:盆栽条件下,设置干旱、轻度干旱和适宜水分处理,探讨了不同生育时期干旱胁迫对大豆根生物量、根冠比、根长、根表面积和根体积的影响。结果表明:在同一控水时期,随着土壤含水量的增加,根冠比逐渐降低。营养生长期(V2~R1)控水,随着土壤含水量的增加,根生物量、根表面积逐渐增加,且适宜水分显著高于干旱,但与轻度干旱间无显著差异,各水分处理间的根长、根表面积无显著差异。花荚期(R1~R5)控水,轻度干旱的根生物量、根体积显著高于干旱处理,适宜水分的根长、根表面积显著高于干旱和轻度干旱处理。鼓粒期(R5~R7)控水,根生物量、根长、根表面积、根体积3个处理间差异不显著。

关键词:水分胁迫;根系特性;大豆

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Effect of Drought Stress at Different Growth Stages on Root Development of Soybean

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Abstract: Soil drought stress directly affect soybean root system. Under pot condition, three water treatment of drought(W1), slight drought(W2) and normal water supply(W3), which was accounting for 50%, 60% and 80% of field water capacity, were adopted at V2-R1, R1-R5, R5-R7, respectively, and root traits were determined. Root to shoot ratio decreased with the increasing of soil moisture when water was controlled at the same growth stage. When soil water content was controlled at V2-R1, root biomass and root surface area increased with the increasing of soil moisture, and was significantly higher under W3 than W1; No significant difference for root length and root surface area were found between three treatments. When soil water content was controlled at R1-R5, root biomass and root volume of W2 were significantly higher than W1, while root length and root surface area in W3 were significantly higher than W1and W2. When soil water content was controlled at R5-R7, root biomass, root length, root surface area and root volume had no significant difference between three treatments.

Key words: Water stress; Root characteristics; Soybean

随着经济和人口增长,水资源短缺现象日益严重,导致干旱地区面积逐渐扩大,干旱化程度逐步加重。大豆是一种需水较多的作物,每形成1 g干物质需要消耗水600~800 g[1],大豆对水分敏感的程度与生育时期密切相关,幼苗期干旱可以促进根系深扎,利于大豆生长发育,开花结荚期需水量较多,此时干旱会严重影响产量的形成。在土壤干旱胁迫条件下,作物最先感受胁迫的器官是根系,通过根系生长和代谢的相应调整以适应逆境胁迫,故而根系抗逆性的研究日益引起重视[2-3]。作物的正常生长发育是地上与地下部形态功能相协调的结果。根系形态决定植株获得水分和养分的能力[4],反映根系特性的指标,包括根长、根面积、平均根直径、根系生物量等[5-6]。土壤水分胁迫影响大豆植株的生长,有关干旱胁迫对大豆光合速率、蒸腾速率、保护酶活性以及地上部株高、生物产量的影响前人做了大量的研究[7-9];水分胁迫对大豆地下根部影响的研究多集中于根生物量和根冠比方面,干旱降低了植株的根生物量,提高根冠比[10]。本文探讨了不同生育时期干旱胁迫对大豆根系发育的影响,以期为大豆逆境生理及高产栽培提供理论依据。

1 材料与方法

1.1 试验设计

试验于2010年在辽宁省农业科学院进行。供试品种为辽豆18。试验采用普通塑料桶,高28 cm,上口直径30 cm,下口直径26 cm。塑料桶放置于全自动遮雨棚中。随机区组设计,设3个水分处理,分别为干旱(W1):土壤含水量为田间持水量的

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50%;轻度干旱(W2):土壤含水量为田间持水量的60%;适宜水分对照(W3):土壤含水量为田间持水量的80%。分别在大豆营养生长期(V2~R1,6月7日~7月8日),花荚期(R1~R5,7月8日~7月31日),鼓粒期(R5~R7,7月31日~8月26日)进行水分调控,各处理组合在非控水时期保持适宜水分。每盆装土15.3 kg,土壤水分测定采用称重法。每盆播4粒,出苗后定苗2株,6次重复。

1.2　测定项目与方法

分别在大豆营养生长期、花荚期、鼓粒期控水结束后取样,以子叶节为界把植株分为地上部分和地下部分(根),将根冲洗干净,用EPSON Scanner扫描,然后用WinRHIZO分析根长、根表面积和根体积。用百分之一电子秤测定根干重及地上部干重。

1.3　数据分析

用Excel 2003和SAS 8.0进行数据分析。

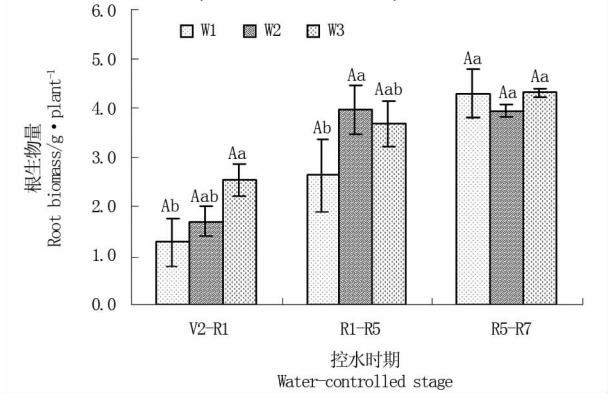
2　结果与分析

2.1　干旱胁迫对大豆根生物量的影响

由图1可知,营养生长期控水,随着土壤含水量的增加,根生物量逐渐增加,处理W3显著高于W1,但与W2间无显著差异;花荚期控水,根系生物量W2>W3>W1,W2显著高于W1;鼓粒期控水,W1、W2、W3的根生物量分别为4.28、3.94、4.29 g·株$^{-1}$,以W3根生物量最大,但三者之间无显著差异。

2.2　干旱胁迫对大豆根冠比的影响

由图2可知,同一控水时期,随着土壤含水量的增加,根冠比逐渐降低,且营养生长期和花荚期控水,W1的根冠比显著高于W3;鼓粒期控水,W1的根冠比显著高于W2和W3。土壤干旱降低了植株根及地上部的生物产量,但由于地上部生物产量降低的更多,导致根冠比增加,说明土壤干旱对地上部的不利影响高于地下部。随着生育进程的推进,植株根冠逐渐降低。



同一控水时期不同大小写字母分别表示0.01和0.05水平差异显著,下同。

Different capital and lowercase letters in the same water control stage are significantly different at 0.01 and 0.05 level, respectively. The same below.

图1　水分胁迫对大豆根生物量的影响

Fig. 1　Effect of soil water stress controlled at different growth stages on soybean root biomass

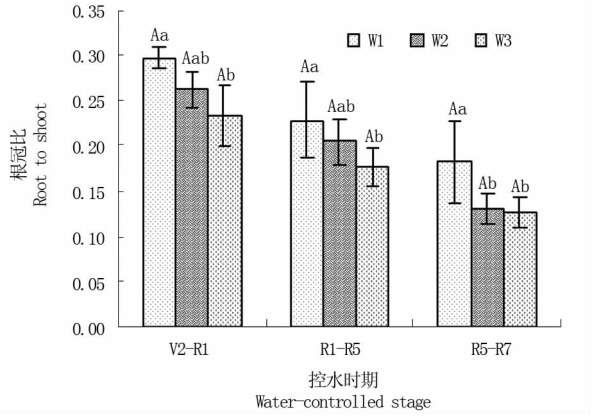


图2　水分胁迫对大豆根冠比的影响

Fig. 2　Effect of soil water stress controlled at different growth stages on soybean root to shoot ratio

2.3　干旱胁迫对大豆根长的影响

由图3可知,营养生长期控水,尽管W2、W3的根长分别比W1增加41.74%和40.29%,但三者间无显著差异;花荚期控水,W3根长大于W2和W1,且达到显著差异水平;鼓粒期控水,以W1根长最大,但3个处理间差异不显著。

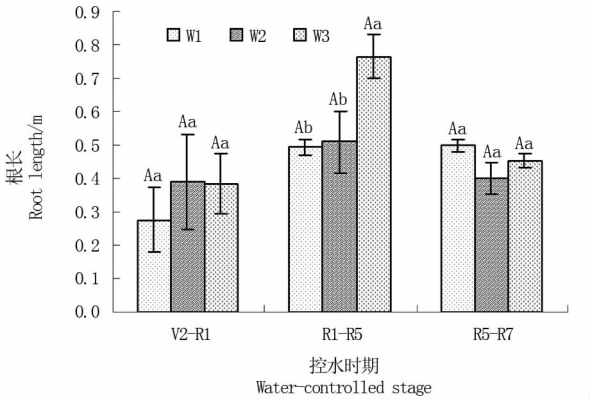


图3　水分胁迫对大豆根长的影响

Fig. 3　Effect of soil water stress on soybean root length

2.4　干旱胁迫对大豆根表面积的影响

由图4可知,营养生长期控水,随着土壤含水量的增加,根表面积逐渐增加,处理W3的根表面积显著高于W1,但与W2无显著差异;花荚期控水,W2、W3的根表面积显著高于W1。鼓粒期控水,W1的根表面积最大,但三者无显著差异。

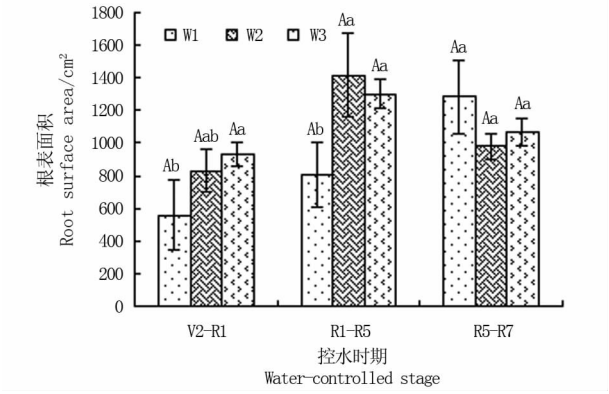


图 4 水分胁迫对大豆根表面积的影响

Fig. 4 Effect of soil water stress on soybean rootsurface area

2.5 干旱胁迫对大豆根体积的影响

由图 5 可知,营养生长期控水,随着土壤含水量的增加,根体积逐渐增大,以 W3 根体积最大(18.30 cm^3),但三者间无显著差异;花荚期控水,W2 的根体积最大,显著高于 W1 和 W3;鼓粒期控水,根体积表现为:W1 > W3 > W2,但三者间无显著差异。各时期控水对根体积的影响表现为,W1:鼓粒期 > 花荚期 > 营养生长期;W2:花荚期 > 鼓粒期 > 营养生长期;W3:鼓粒期 > 营养生长期 > 花荚期。

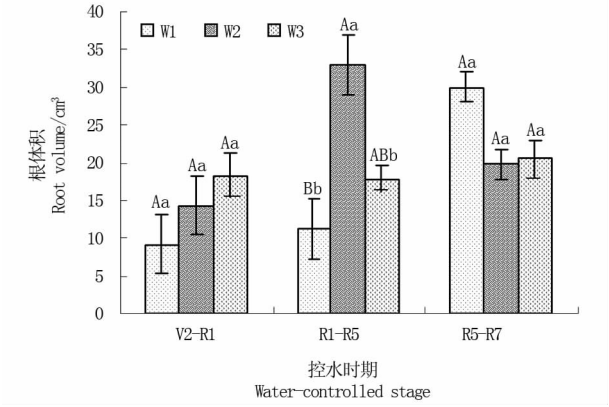


图 5 水分胁迫对大豆根体积的影响

Fig. 5 Effect of soil water stress on soybean root volume

3 讨 论

本试验中,各时期控水,随着土壤含水量的增加,根冠比逐渐降低,干旱对地上部分的影响比对根系的影响更大。胡继超等[11]认为干旱胁迫对小麦地上部的影响大于地下部,干物质向根的分配比例升高,导致根冠比增大,这与本试验结果一致。

根系形态决定作物获得养分和水分的能力,根长、根表面积和根体积都直接影响着作物对水分和养分的吸收和运输能力[12-13]。本试验中营养生长期控水,适宜水分下的根生物量、根表面积显著高于干旱胁迫,但与轻度干旱无显著差异。花荚期控水,适宜水分的根长、根表面积显著高于干旱和轻度干旱,且轻度干旱的根生物量、根体积显著高于干旱胁迫。鼓粒期(R5 ~ R7)控水,根生物量、根长、根表面积和根体积在 3 个处理间均无显著差异。刘丽君等[14]的研究表明,苗期干旱胁迫增加了大豆的根体积、根长、根总表面积,而其它时期的干旱胁迫减缓大豆根形态发育。与本试验结果存在差异,原因可能与试验环境、控水方式不同有关。李博等[15]通过研究不同干旱方式和程度对盆栽玉米根系发育的影响,指出渐进干旱方式条件下,根系在轻度干旱时生长最好,严重干旱时最差;而直接干旱方式条件下,根系在水分充足时生长最好,轻度干旱次之,严重干旱时最差。由此可见,干旱对植株根系的影响因干旱方式和程度的不同而存在差异。

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