干旱胁迫对春大豆开花期根系生理特性的影响

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摘 要:为明确大豆根系生理特性的变化与抗旱性的关系,在盆栽条件下,以3个抗旱性不同的大豆品种为材料,测定开花期根系相对含水率、根系活力、丙二醛含量、超氧化物歧化酶和过氧化物酶活性。结果表明:大豆根系相对含水率及根系活力随干旱胁迫程度增强而降低,抗旱品种降低程度小于不抗旱品种;根系丙二醛含量随干旱程度的增加而升高,各品种间无明显差异;抗旱品种超氧化物歧化酶活性随干旱程度的增加而升高,而不抗旱品种则表现为先升高后降低趋势;过氧化物酶活性各品种间随着干旱胁迫程度的加强均呈先升高后降低趋势,抗旱品种变化更为明显。干旱胁迫下大豆通过改变根系内部的生理变化以提高其抗旱性。

关键词:大豆;干旱胁迫;超氧化物歧化酶;过氧化物酶;丙二醛

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Effects of Drought Stress on Physiological Characteristics of Root System of Spring Soybean in Flowering Period

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Abstract: The paper aimed to study the relation of drought resistance and the changes of physiological characteristics of soybean root system. It chose three varieties of soybean with different drought resistance potted in pots as experimental samples. The results showed that the relative moisture content and activity of soybean root system reduced with the increasing of drought stress degree, and the reduction level of the variety of soybean with strong drought-resistance was less than the weak one. The content of Malonaldehyde (MDA) of soybean root system rose with increasing the degree of drought, and there was no obvious difference among three varieties of soybean. The activity of Superoxide Dismutase(SOD) in the variety of soybean with strong resistance rose with increasing the level of drought, but the weak one showed increased in the beginning and then decreased. The Peroxidase (POD) activity of all varieties had the tendency of increasing in the beginning period and then decreasing, however, such change appeared in soybean with strong resistance was remarkable. In conclusion, the soybean in the condition of drought stress could increase its drought resistance by changing the physiological characteristics of the root system.

Key words: Soybean; Drought stress; SOD; POD; MDA

水分胁迫是植物受到的危害中最普遍的形式之一[1]。水分作为作物生长代谢的基础,是作物不可或缺的组成部分。有关植物抗性生理的研究表明,细胞生理生化方面的变化与植物的耐旱性有关,且植物对逆境胁迫的敏感性因植物类型、品种、生育期不同而有很大差异[2-4]。近年来,许多学者对大豆抗性生理生化机制进行了广泛深入的研究,并提出了许多与抗旱性有关的生理生化指标[5]。但是目前对于植物抗旱性的研究主要集中于地上部分的生理生化特性等方面[6]。由于试验条件和采集、保存根系鲜样方法等方面的限制,对地下部分根系抗旱性的研究较少,且多集中于根系的生长特征方面[7]。根系作为植物吸收水分和养分的主要器官,也是最早感受土壤干旱的器官,在干旱胁迫条件下,研究根系生理代谢对于大豆抗旱性研究有重要意义。该研究选取3个抗旱性不同的大豆品种,研究了开花期不同程度水分胁迫对大豆根系生理指标影响,以期为大豆高产栽培提供理论依据。

1 材料与方法

1.1 供试材料

供试品种为抗旱性不同的3个大豆品种黑农

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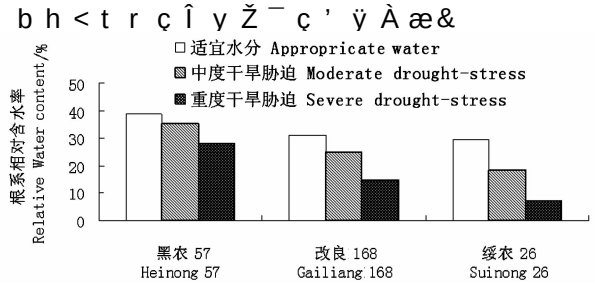

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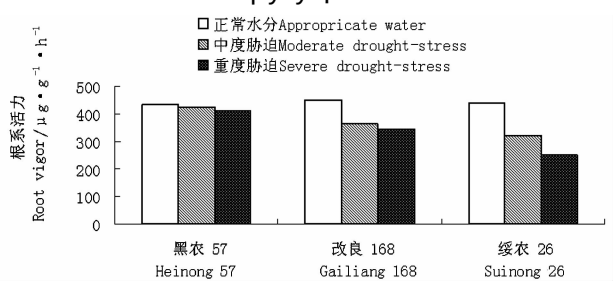

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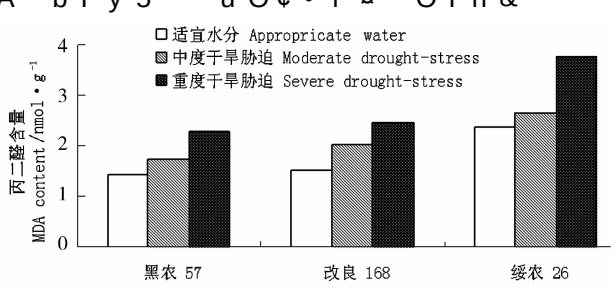

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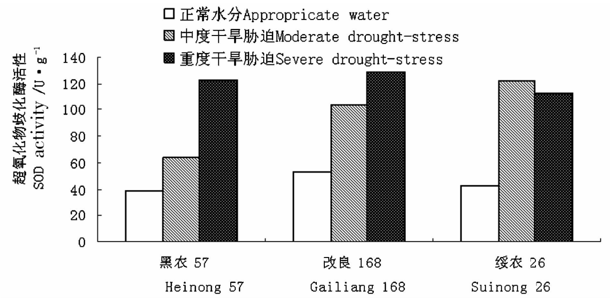

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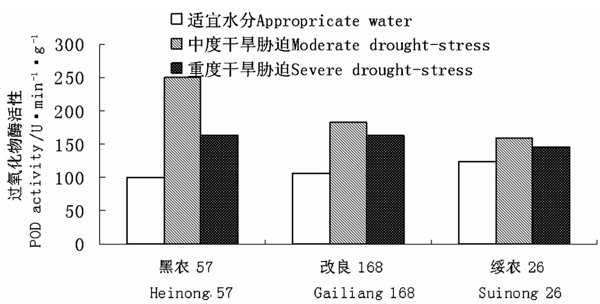

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参考文献

[1] 元明浩,孟广萍,朱阳阳. 不同植物生长调节剂对大豆产量及生长形态的影响[J]. 安徽农业科学, 2009, 37 (35):17447 - 17449. (Yuan M H ,Meng G P, Zhu Y Y. Effects of different plant growth regulators on the yield and grow shape of soybean[J]. Journal of Anhui Agricultural Sciences, 2009, 37 (35):17447 - 17449.)

[2] 姚雄,杨文钰. 化学调控技术在我国大豆生产上的应用与展望[J]. 安徽农学通报, 2007, 13(3):61 - 63. (Yao X, Yang W Y. Application and prospect of chemic regulating technique on Chinese soybean planting[J]. Anhui Agricultural Science Bulletin, 2007, 13 (3):61 - 63.)

[3] 王庆祥,吕桂兰,Feng Zhang,等. GA3 和 kinetin 在低温下对玉米和大豆种子萌发及幼苗发育影响的研究[J]. 作物学报, 1999,25(3):363 - 272. (Wang Q X, Lv G L, Zhang F, et al. GA3 and kinetin stimulate the germination of corn and soybean seeds at low temperatures[J]. Acta Agronomica Sinica, 1999, 25 (3):363 - 372.)

[4] 张明才,何钟佩,田晓莉,等. 植物生长调节剂 BR 和 SHK-6 对大豆生物产量和根瘤固氮活性的激素调控研究[J]. 大豆科学, 2004, 23(2):96 - 100. (Zhang M C, He Z P, Tian X L, et al. Hormonal regulation of plant growth regulator BR and SHK-6 on soybean biomass and nitrogenase activity[J]. Soybean Science, 2004, 23 (2):96 - 100.)

[5] 陆剑飞. 四种植物生长调节剂对茶叶产量与品质的影响[J]. 浙江农业学报, 2006, 18(3):192 - 194. (Lu J F. The influence of plant growth regulators on the yield and quality of tea[J]. Acta Agriculturae Zhejiangensis, 2006, 18 (3):192 - 194.)

[6] 张志良. 植物生理学实验指导(第三版)[M]. 北京:高等教育出版社, 2003:154 - 156, 127 - 128, 138 - 139. (Zhang Z L. Experimental guiding of plant physiology(the third)[M]. Beijing: Higher Education Press, 2003: 154 - 156, 127 - 128, 138 - 139.)

[7] 孙炳剑,郑先福,郑昊. 复硝酚钠急性毒性的初步研究[J]. 河南农业大学学报, 2007, 41(1):73 - 76. (Sun B J, Zheng X F, Zheng H. A preliminary study on acute toxicity of compound sodium nitrophenolate[J]. Journal of Henan Agricultural University, 2007, 41(1):73 - 76.)

[8] 郑先福,孙炳剑,郑昊. 复硝酚钠的致突变性研究[J]. 河南科技大学学报:自然科学版, 2007, 28(4):94 - 97. (Zheng X F, Sun B J, Zheng H. Study on mutagenicity of compound sodium nitrophenolate[J]. Journal of Henan University of Science and Technology: Natural Science, 2007, 28(4):94 - 97.)

[9] 李清芳,范永红,马成仓. 大豆种子萌发过程中蛋白质、脂肪和淀粉含量的变化[J]. 安徽农业科学,1998,26(4):209 - 300. (Li Q F, Fan Y H, Ma C C. The changes of protein, fat and starch content during soybean seed germination[J]. Journal of Anhui Agricultural Sciences, 1998,26(4):209 - 300.)

(上接第 439 页)

参考文献

[6] 胡新生,王世绩. 树木水分胁迫生理与耐旱性研究进展及展望[J]. 林业科学, 1998, 34(2): 77 - 89. (Hu X S, Wang S J. A review of studies on water stress and drought tolerance in tree species [J]. Scientia Silvae Sinicae, 1998, 34(2): 77 - 89.)

[7] Rhodenbaugh E J, Pallardy S G. Water stress, photosynthesisand early growth patterns of cuttings of three populus clones[J]. Tree Physiology, 1993, 13(3): 213 - 226.

[8] 张志良,瞿伟菁. 植物生理学实验指导(第 3 版)[M]. 北京: 高等教育出版社,2003: 267 - 269. (Zhang Z L, Qu W J. Experimental guidance for plant physiology (The 3rd Version) [M]. Beijing: China Higher Education Press, 2003: 267 - 269.)

[9] 李合生. 植物生理生化实验原理和技术[M]. 北京: 高等教育出版社,2000: 164 - 165,260 - 261. (Li H S. Experimental principle and technology of plant biochemistry [M]. Beijing: China Higher Education Press, 2000: 164 - 165, 260 - 261.)

[10] 张宪政. 作物生理研究法[M]. 北京: 农业出版社,1992: 206 - 215. (Zhang X Z. Researc hmethods of crop physiolog[M]. Beijing: China Agriculture Press, 1992:206 - 215.)

[11] 陈晓远,高志红,罗远培,等. 不同土壤水分冬小麦根、冠关系及其对叶片水分利用效率的影响[J]. 中国生态农业学报, 2005, 13(2): 134 - 137. (Chen X Y, Gao Z H, Luo Y P, et al. Relationships between root and shoot of winter wheat under different soil water conditions and their effects on the water use efficiency[J]. Chinese Journal of Eco - Agriculture, 2005, 13(2): 134 - 137.)

[12] 赵世杰. 植物组织中丙二醛测定方法的改进[J]. 植物生理学通讯, 1994, 30(3): 207 - 210. (Zhao S J. The improvement of assay method of malonaldehyde in plant tissue[J]. Plant Physiology Communications, 1994, 30(3): 207 - 210.)

[13] Mclord J M. Superoxide dismutase: An enzymic function for erythrocuprein (*hemocupreim*) [J] Journal of Biological Chemistry, 1969, 224: 6049 - 6055.

[14] 刘学师,刘新根,任小林. 酸枣根系抗旱性研究[J]. 河北农业大学学报, 2007, 30(6): 34 - 36. (Liu X S, Liu X G, Ren X L. Study on drought resistance of the root for *Ziziphus* var. *spinosa* Hu [J]. Journal of Agricultural University of Hebei, 2007, 30(6): 34 - 36.)

[15] 王启明,郑爱珍,吴诗光. 干旱胁迫对花荚期大豆叶片保护酶活性和膜脂过氧化作用的影响[J]. 安徽农业科学, 2006, 34(8): 1528 - 1530. (Wang Q M, Zeng A Z, Wu S G. Effects of drought - stress on protective enzyme activity and membrane lipid peroxidation in leaf of soybean flowering - poding period[J]. Journal of Anhui Agricultural Sciences, 2006, 34(8): 1528 - 1530.)

[16] 冯彩平. 土壤干旱对冬小麦功能叶过氧化物酶同工酶及抗旱性的影响[J]. 水土保持通报, 1996, 16(4): 46 - 50. (Feng C P. Effect of soil drought on the peroxidase isoenzyme and drought resistance of winter wheat[J]. Bulletin of Soil and Water Conservation, 1996, 16(4): 46 - 50.)