淹水胁迫对不同耐涝性大豆品种苗期根部形态及叶部生理指标的影响

宋晓慧[1,2],滕占林[2],箫长亮[3],李冬梅[1],李文滨[1],张代平[2]

(1. 东北农业大学大豆生物学教育部重点实验室,东北农业大学农业部东北大豆生物学与遗传育种重点实验室,黑龙江 哈尔滨 150030;2. 黑龙江省农垦科学院 农作物开发研究所,黑龙江 佳木斯 154007;3. 黑龙江省农垦科学院 水稻研究所,黑龙江 佳木斯 154007)

摘 要:对10个不同耐涝性大豆品种采用双层套盆法进行淹水胁迫处理7 d,对比不同品种的死苗率差异,研究了淹水胁迫对大豆不定根数、根瘤数及叶部生理指标的影响。结果表明,与不耐涝的品种相比,耐涝品种死亡率低、不定根数量多,通气组织发达,根瘤数多,叶片的相对电导率、丙二醛含量及脯氨酸含量较低,且各指标的差异达显著水平。

关键词:大豆;淹水胁迫;苗期,根部形态,叶部生理指标

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Effect of Waterlogging on Root Morphology and Foliar Physiological Indexes of Soybean Varieties

SONG Xiao-hui[1,2], TENG Zhan-lin[2], XIAO Chang-liang[3], LI Dong-mei[1], LI Wen-bin[1], ZHANG Dai-ping[2]

(1. Key Laboratory of Soybean Biology in Chinese Ministry of Education, Key Laboratory of Soybean Biology and Breeding/Genetics of Chinese Agriculture Ministry, Northeast Agricultural University, Harbin 150030, Heilongjiang; 2. Crop Research Institute, Land-Reclaimable Sciences of Heilongjiang Province, Jiamusi 154007, Heilongjiang; 3. Rice Research Institute, Land-Reclaimable Sciences of Heilongjiang Province, Jiamusi 154007, Heilongjiang, China)

Abstract: Waterlogging is one of natural disasters affected the yield and quality of soybean adversely. Soybean is very sensitive to waterlogging at seedling, an detailed understanding on changes of root morphology and foliar physiological indexes under waterlogging stress will facilitate the screening of varieties resistant to waterlogging. In this study, 10 soybean varieties were tested under artificial waterlogging for 7 days in double pots at seedling stage to research the changes of root morphology and foliar physiological indexes. There were significant differences between varieties for tested traits. Compared with the intolerant varieties, tolerant varieties had more adventitious roots and root nodules, developed better aerenchyma, and had lower relative conductivity, malondialdehyde and proline content in leaves.

Key words: Soybean; Waterlogging stress; Seedling stage; Root morphology; Foliar physiological indexes

大豆遭受涝害后由于根系缺氧,造成烂根、严重的甚至死亡,给大豆生产带来严重损失。不同大豆品种对涝害的耐性存在差异[1],而明确这种耐性差异的生理机制对于耐涝性品种的选育具有重要意义。近年来,相关研究多集中于涝害对于大豆生长发育及根部生理指标的影响[2-5],而对涝害下大豆叶部生理指标研究报道较少,植物耐涝性是一个综合的性状,单一的性状不能较全面地衡量耐涝性。因此本研究选择耐涝性不同的大豆品种,探讨在苗期淹水胁迫条件下根部形态指标及叶部生理指标变化,为大豆耐涝性品种的筛选奠定基础。

1 材料与方法

1.1 试验设计

试验于2012年在黑龙江省农垦科学院农作物开发研究所网室进行,供试大豆品种有垦丰16、垦丰23、黑农64、黑农48、垦丰18、绥农26、垦丰17、垦丰14、合丰50和合丰55。试验采用双层套盆的盆栽方法进行,即盆内种植大豆,盆外套塑料桶,内部盆钵为直径20 cm,高25 cm,外部塑料桶为直径30 cm,高32 cm。供试土壤前茬为玉米,其土壤养分含量如下,碱解氮163.6 mg·kg^{-1},速效磷34.8 mg·kg^{-1},速效钾267.6 mg·kg^{-1},有机质4.5 g·kg^{-1},pH7.2。土壤粉碎后,每盆装土2.5 kg,盆底有排水孔。每品种各20盆,每盆保苗3株,于大豆3片复叶期进行淹水处理,对外部塑料桶进行灌水,以水没过盆5 cm为标准。淹水处理7 d后,倒掉桶中剩余水分,2 d后,计算不同品种死苗率,调查存活植株的不定根数和根瘤数,测定叶片的相对电导率、丙二醛和游离脯氨酸含量。

1.2 测定项目与方法

相对电导率(浸泡液电导率值/煮沸后电导率值)采用电导仪法测定;游离脯氨酸含量采用酸性茚三酮法测定;丙二醛含量采用硫代巴比妥酸法测定[6]。

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第一作者简介:宋晓慧(1978-),女,在读博士,助理研究员,研究方向为大豆生物育种。E-mail:kxysxh09@163.com。

通讯作者:张代平(1962-),男,研究员,从事大豆栽培研究。E-mail:kxyzdp@163.com。

1.3　数据分析

采用 Excel 2003 和 DPS 9.5 软件进行单因素方差分析,用 LSD 法进行多重比较。

2　结果与分析

2.1　死苗率及根部形态指标

淹水 3 d 开始,部分品种叶片开始变黄,7 d 后,开始出现死苗现象。如表 1 所示,参试品种间死苗率差异极显著,垦丰 16 死苗率最高(87.5%),其次是垦丰 23(69.6%),垦丰 14 最低。

经淹水处理后,茎秆基部变粗,处于水层中的茎基部长出大量不定根;各品种均出现了呈白色海绵体状的通气组织,耐涝性强的品种通气组织发达,而耐涝性差的品种通气组织不发达。如表 1 所示,不同品种均出现不定根,但是数量存在显著差异,其中垦丰 14(22.8 个)最多,垦丰 16(3.5 个)最少。不同品种的根瘤数显著差异,同样是垦丰 14(6.5 个)最多,垦丰 16(1.3 个)最少。

表 1　不同耐涝性品种死苗率及根部形态指标差异

Table 1　Death rate and root morphological character of soybean varieties with different waterlogging tolerance

品种 Varieties	死苗率 Death rate/%	单株不定根数 Adventitious root number per plant	株根瘤数 Root nodule number per plant
垦丰 23 Kenfeng23	69.57bB	4.0efE	2.0eD
垦丰 16 Kenfeng16	87.50aA	3.5fE	1.3fgF
黑农 64 Heinong64	42.86cC	7.5cdDE	4.1cB
黑农 48 Heinong48	35.00dD	10.0cCD	3.0dC
垦丰 18 Kenfeng18	20.83fF	3.8efE	0.9gF
绥农 26 Suinong26	7.14hH	16.5bB	4.6bB
垦丰 17 Kenfeng17	16.00gG	14.0bBC	3.4dC
垦丰 14 Kenfeng14	0.00iI	22.8aA	6.5aA
合丰 50 Hefeng50	20.83fF	6.5deDE	1.9eDE
合丰 55 Hefeng55	28.57eE	7.6cdDE	1.4fEF

数值后不同大小写字母分别代表 0.01 和 0.05 水平差异显著,下同。

Values followed by different capital and lowercase letters are significantly different at 0.01 and 0.05 probability level, respectively; the same below.

2.2　叶部生理指标

由表 2 可知,耐涝性品种叶片的电导率、丙二醛含量和脯氨酸含量均显著或极显著低于不耐涝品种,如垦丰 14,其电导率、丙二醛含量和游离脯氨酸含量均为最低;而垦丰 16 耐涝性最差,其电导率最高,除与垦丰 23 差异不显著外,极显著高于其他品种,其丙二醛含量和游离脯氨酸含量均极显著高于其他品种。

表 2　不同品种淹水胁迫下叶部生理指标差异

Table 2　Leaf morphological indexes of different soybean varieties

品种 Varieties	电导率 Relative conductivity/%	丙二醛含量 MDA content/mol·g^{-1}	脯氨酸含量 Proline content/μg·g^{-1}
垦丰 23 Kenfeng23	19.2abAB	106.82dD	590.0abAB
垦丰 16 Kenfeng16	20.7aA	197.96aA	607.2aA
黑农 64 Heinong64	16.5bcBC	74.64ee	510.6cdeBCD
黑农 48 Heinong48	13.3cde	142.70bB	491.0deDE
垦丰 18 Kenfeng18	12.3deCDE	142.84bcBC	510.6deDE
绥农 26 Suinong26	8.8fgEF	55.92fF	517.5deCD
垦丰 17 Kenfeng17	6.3gF	55.89fF	524.4bcdBCD
垦丰 14 Kenfeng14	7.9fgEF	50.64fF	437.0fE
合丰 50 Hefeng50	15.4cdBCD	75.97eE	556.3bcABC
合丰 55 Hefeng55	10.6efDE	138.42cC	463.3efDE

3 讨论

3.1 淹水胁迫对根部形态的影响

淹水胁迫下,大豆植株均有不定根和通气组织的生成,取代受到伤害而失去功能的初生根,积极地进行氧气、养分和水分的吸收与运输,从而提高了大豆植株的耐涝性,使得大豆叶片一些生理功能得以正常运行。这与 Went[7] 的结果相一致。耐涝性强的品种死苗率低,植株不定根数多,通气组织发达,根瘤数量多。另外,本研究中发现不定根可以结瘤,这与倪君蒂等[2] 的报道一致。

3.2 淹水胁迫对叶片生理指标的影响

在淹水胁迫条件下,大豆植株根系发育受阻,营养物质吸收与运输能力减弱,叶部光合能力受阻,细胞发生膜脂过氧化反应,产生游离脯氨酸和丙二醛。但是,耐涝性好的品种通过大量不定根发生及通气组织形成,加大了氧气、水分和无机盐吸收与运输,降低了淹水胁迫对植株叶片造成的伤害,质膜受伤害的程度轻,使得相对电导率、丙二醛和脯氨酸含量均低于不耐涝品种。

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