

陆地棉 *CBL* 基因家族成员鉴定与功能分析

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摘要: 钙调磷酸酶 B 亚基蛋白 (calcineurin B-like proteins) 在植物非生物逆境应答以及钙信号转导过程发挥重要的作用。为了探究 *CBL* 基因在棉花非生物胁迫响应的作用,本研究利用生物信息学的方法进行陆地棉 *CBL* 家族成员的鉴定,利用转录组数据和反转录聚合酶链式反应分析陆地棉 *CBL* 基因在盐胁迫下的表达模式,利用病毒诱导的基因沉默技术对 *GhCBL10-1* 基因进行沉默并进行功能验证。结果表明,在陆地棉中获得 25 个 *CBL* 基因,该基因家族成员蛋白的理化性质差异不大,*CBL* 蛋白中的氨基酸大部分为酸性。系统进化树分析将陆地棉的 *CBL* 蛋白分成了 2 个组,其中 A 组包括 *GhCBL4-1*、*GhCBL4-2*、*GhCBL4-3*、*GhCBL4-4*、*GhCBL4-5*、*GhCBL8*,其他成员属于 B 组;通过结构域和保守基序分析发现所有的 *CBL* 基因均含有至少 1 个 EF-hand 结构域。基因结构分析发现同一类群中外显子-内含子结构比较相似,不同组之间的基因结构差异较大。染色体定位分析发现 24 个 *CBL* 基因被定位在 19 条染色体上,其中 13 个 *CBL* 基因定位在 A 亚组染色体上,*GhCBL1-7* 不能定位到任何染色体上,剩余的基因定位在 D 亚组染色体上。陆地棉 *CBL* 家族基因成员启动子区域中均含有多个能够应答逆境和植物激素的顺式作用元件。在盐胁迫下,15 个基因在叶和根中有显著的差异表达,且在根和叶中的差异表达模式不同。利用病毒诱导的基因沉默技术成功沉默 *GhCBL10-1* 的棉株相较于对照更加不耐盐。该研究结果有助于了解陆地棉 *CBL* 基因家族的进化与功能,为后续研究其功能提供了一定的理论依据。

关键词: 陆地棉;钙调磷酸酶 B 亚基蛋白;病毒诱导基因沉默;基因功能

Identification and bioinformatics analysis of *CBL* family gene in *Gossypium hirsutum*

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Abstract: Calcineurin B-like (*CBL*) proteins play an important role in plant abiotic stress response and calcium signal transduction. In order to explore the role of *CBL* gene in cotton abiotic stress response, this study used bioinformatics methods to identify *CBL* family members in *Gossypium hirsutum*, and analyzed the expression pattern of *CBL* gene in upland cotton under salt stress by using transcriptome data and reverse transcription polymerase chain reaction. The virus induced gene silencing technique was used to silence *GhCBL10-1* gene and to verify its function. The results showed that 25 *CBL* genes were obtained from upland cotton, and there was little difference in physiochemical properties of the member proteins. Most of the amino acids in *CBL* proteins were acidic. The *CBL* proteins of upland cotton were divided into two groups by phylogenetic tree analysis. Group A included *GhCBL4-1*, *GhCBL4-2*, *GhCBL4-3*, *GhCBL4-4*, *GhCBL4-5* and *GhCBL8*, and the other members belonged to group B. Domain and conserved motif analysis showed that all *CBL* genes contain at least one EF-hand domain. The analysis of gene structure showed that exon-intron structure was similar in the same group, and the gene structure was different among different groups. Chromosome localization analysis showed that 24 *CBL* genes were located on 19 chromosomes, of which 13 *CBL* genes were located on subgenome A chromosomes, *GhCBL1-7* could not be mapped to any chromosome, and the remaining genes were located on subgenome

D chromosomes. The promoter region of *CBL* family gene members in upland cotton contains multiple *cis*-acting elements that can respond to stress and plant hormones. Under salt stress, 15 genes were significantly differentially expressed in leaves and roots, and the differentially expressed patterns were different in roots and leaves. Cotton plants successfully silenced with *GhCBL10-1* by virus induced gene silencing were more sensitive to salt stress than control plants. The results of this study are helpful to understand the evolution and function of *CBL* gene family in upland cotton, and provide a theoretical basis for further study of its function.

Keywords: *Gossypium hirsutum*; calcineurin B subunit protein; virus induced gene silencing; gene function