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# 杂交水稻专题

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## 前沿资讯

### 1．科技创新进展：利用基因编辑技术调控水稻遗传重组频率

**简介：**近日，中国水稻研究所王克剑团队在植物学知名期刊Plant Communications在线发表了题为“Manipulation of genetic recombination by editing the transcriptional regulatory regions of meiotic Ogene in hybrid rice”的文章。该研究利用CRISPR/Cas9基因编辑技术对水稻重组关键基因HEI10的转录调控区域进行编辑，不同等位突变植株不仅保证了减数分裂期染色体的正常分离，还保留了较高的结实率，同时突变植株中遗传重组频率也发生了不同程度的增加或减少，文章结果表明通过对单个重组关键基因转录调控区域的编辑可以实现对遗传重组的正向和负向调控，为加速新品种的培育，缩短育种周期提供重要理论基础和技术支撑。遗传重组是动植物遗传育种过程中遗传多样性的主要来源之一，其特异发生在生殖发育的减数分裂时期，增加遗传重组频率可以提高遗传多样性，促进新组合的产生；而重组频率的减少则可以保持已聚合优异性状的稳定。此外，遗传重组的完全消失甚至可用于实现杂种优势的固定与稳定遗传。在多数动植物中，每条染色体上一般只发生1-2次的重组，且重组发生的位置受到严格的限制。目前为止，已在不同物种中克隆了众多调控遗传重组的基因。然而，这些基因的突变植株通常会表现出结实率严重下降，甚至完全不育的表型，从而限制了相关突变体在遗传育种中的应用。研究人员首先分别对水稻HEI10基因的启动子区域和5′ UTR区域进行了多靶点敲除，获得了一系列纯合突变或双等位突变材料。其中，启动子区域被编辑的突变体中HEI10基因的表达量表现不同程度降低，相反，5′ UTR区域被编辑的突变体中HEI10基因的表达量表现不同幅度升高。表型性状调查显示，突变体的营养生长和花粉育性与野生型相比没有明显的差异，并且植株保持了较高的结实率。通过细胞学观察发现这些突变体的染色体能够正常分离，但是，对减数第一次分裂中期二价体的形态进行统计结果显示重组交换的数目可能发生了变化。随后，研究人员进一步通过遗传学分析检测了遗传重组的变化规律与基因表达之间的关系，在启动子区域被编辑的突变体中，重组频率随着HEI10基因表达水平的降低而减少；在5′ UTR区域被编辑的突变体中，重组频率随着HEI10基因表达水平的升高而增加。遗传干涉的统计结果显示，重组频率减少的突变体干涉强度增强，而重组频率增加的突变体干涉强度减弱，表明遗传干涉与重组频率呈现一定的负相关性。该研究揭示了通过对单个关键基因进行编辑可以实现水稻遗传重组的正向和负向调控。已有研究表明有大量基因参与遗传重组的形成过程，因此，研究人员提出通过对更多关键基因进行同步编辑，有望实现对遗传重组更大幅度的调控。此外，由于遗传重组过程在不同动植物中较为保守，该研究思路也有望适用于其它动植物的理论研究和新品种培育。

**来源：**中国水稻研究所

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### 2．研发出新一代遗传育种智能模拟平台

**简介：**中国农业科学院作物科学研究所作物生物信息学及应用创新团队自主研发了新一代模块化遗传育种智能计算机仿真模拟Blib平台，为作物育种方法和育种流程的比较和优化、生物信息和遗传大数据的有效育种利用、分子设计育种和全基因组选择等领域的

研究工作提供了实用的模拟预测和决策支持计算机工具，相关研究结果已经获得国家版权局计算机软件著作权登记证书（登记号：2020SR123853），并于近日在线发表于《生物学通讯（Communications Biology）》上。育种是一个复杂和长期的过程。不同育种家采用不尽相同的育种方法，理论上或通过田间试验比较不同方法的育种成效是十分困难的。采用模拟预测方法可以建立较为真实的遗传模型，在育种家进行田间试验之前，对育种程序中的各种因素进行模拟筛选和优化，提出最佳的亲本选配和后代选择策略，从而提高育种过程中的预见性。计算机仿真模拟工具研发是开展模拟研究的前提。研究人员构建了一个适合于所有二倍体物种（或减数分裂行为与二倍体相似的多倍体物种）的通用计算机仿真模拟平台，称之为Blib。平台能够处理目前已知的所有遗传模型，包括细胞质信息、细胞核基因组信息、加性-显性-上位性效应模型、遗传连锁、突变、雌雄配子育性等；可以模拟产生各种类型的遗传和育种群体，包括自交群体、杂交群体、随机交配群体、无性系繁殖群体；有选择群体、无选择群体等等。基于Blib平台，开发了适宜于特定物种、特定育种方法、特定遗传现象的各种应用程序和模块，进而模拟优化遗传育种方法，对特定亲本杂交后代的表现进行预测。这些模块能够将大量的遗传信息与育种家的育种需求结合起来，供育种家在开展田间试验之前模拟预测不同的杂交和选择方案，比较不同育种方法的优劣，设计最优的育种亲本和育种方案，育种过程中获得实时决策，最终实现遗传研究、分子设计与传统育种的有机结合。Blib平台及其应用模块为即将到来的基于大数据和智能化决策的育种4.0时代提供必不可少的技术支撑。

**来源：**中国农业科学院作物科学研究所

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## 学术文献

### 1. Senescence-Specific Expression of RAmy1A Accelerates Non-structural Carbohydrate Remobilization and Grain Filling in Rice (Oryza sativa L.)(RAmy1A的衰老特异性表达促进水稻（Oryza sativa L.）非结构性碳水化合物的再活化和籽粒灌浆)

**简介：**Remobilization of pre-anthesis NSCs (non-structural carbohydrates) is significant for effective grain filling in rice (Oryza sativa L.). However, abundant starch particles as an important component of NSCs are still present in the leaf sheath and stem at the late stage of grain filling. There are no studies on how bioengineering techniques can be used to improve the efficiency of NSC remobilization. In this study, RAmy1A was expressed under the senescence-specific promoter of SAG12, which was designed to degrade starch in the leaf sheath and stem during grain filling. RAmy1A mRNA successfully accumulated in the leaf, stem, and sheath of transgenic plants after anthesis. At the same time, the starch and total soluble sugar content in the leaf, stem, and leaf sheath were obviously decreased during the grain-filling period. The photosynthetic rate of transgenic lines was higher than that of the wild types by an average of 4.0 and 9.9%, at 5 and 10 days after flowering, respectively. In addition, the grain-filling rate of transgenic lines was faster than that of the wild types by an average of 26.09%. These results indicate an enhanced transport efficiency of NSCs from

source tissues in transgenic rice. Transgenic rice also displayed accelerated leaf senescence, which was hypothesized to contribute to decreased grain weight.

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## 2. Smash ridge tillage strongly influence soil functionality, physiology and rice yield(碎垄耕作严重影响土壤功能、生理和水稻产量)

**简介：**The practice of smash-ridging on dry land crop cultivation has shown much promise. However, the mechanism how does soil functionality and root traits can affect rice yield under smash ridge tillage with reduced nitrogen fertilization have not yet been explored. To fill this knowledge gap, we used three tillage methods-smash-ridging 40 cm (S40), smash-ridging 20 cm (S20), and traditional turn-over plowing 20 cm (T)-and two rice varieties (hybrid rice and conventional rice) and measured soil quality, root traits, rice yield and their correlation analysis at different growth stages. Soil physical and chemical properties were significantly improved by smash-ridging, including improvements in root morphological and physiological traits during three growth stages compared with T. S40 had the highest leaf area index (LAI), plant height (PH), and biomass accumulation (BA). Increment in biomass and panicle number (PN) resulted in higher grain yield (GY) of 6.9-9.4% compared with T. Correlation analysis revealed that root total absorption area (RTAA), root active absorption area (RAA), and root area ratio (RAR) were strongly correlated with soil quality. Root injury flow (RIF) and root biomass accumulation (RBA) were strongly correlated with LAI and above-ground plant biomass accumulation (AGBA). Conclusively, S40 is a promising option for improving soil quality, root traits, and consequently GY. (C) 2020 The Authors. Published by Elsevier B.V. on behalf of King Saud University.

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## 3. Characterization of rice cultivar response to florpyrauxifen-benzyl(水稻品种对氟吡鲁昔芬苄基的反应特性)

**简介：**Many factors such as environment, herbicide rate, growth stage at application, and days between sequential applications can influence the response of a crop to herbicides. Florpyrauxifen-benzyl is a new broad-spectrum, POST herbicide that was commercialized for use in U.S. rice production in 2018. Field experiments were conducted in 2018 at the Pine Tree Research Station (PTRS) near Colt, AR, and the Rice Research and Extension Center (RREC), near Stuttgart, AR, to evaluate crop injury and yield response of three rice cultivars to sequential applications of florpyrauxifen-benzyl. Greenhouse and growth chamber experiments were conducted at the Altheimer Laboratory in Fayetteville, AR, to evaluate

cultivar responses when florpyrauxifen-benzyl was applied at 30 or 60 g ae ha(-1) to rice exposed to different temperature regimes or at various growth stages. Three rice cultivars were used in all experiments: long-grain variety 'CL111', medium-grain variety 'CL272', and long-grain hybrid cultivar 'CLXL745'. CL111 exhibited sufficient tolerance to florpyrauxifen-benzyl with only 10% visible injury and no effect on yield. CL272 showed 15% injury 3 wk after the second application in the field experiment when applications were made 14 d apart. Additionally, 12% injury was observed in greenhouse studies when florpyrauxifen-benzyl was applied at 30 g ae ha(-1,) averaged over various growth stages at application. Florpyrauxifen-benzyl did not reduce the yield of CL272 in field experiments, indicating that CL272 can recover from florpyrauxifen-benzyl injury. As much as 64% injury was observed for CLXL745 at 3 wk after application (WAA) when sequential herbicide applications were made 4 d apart. High levels of injury occurred in the growth chamber and greenhouse studies for this cultivar as well. Sequential applications of florpyrauxifen-benzyl reduced yields of CLXL745 in nearly all treatments. Data from these experiments suggest that CL272 and CLXL745 are sensitive to sequential applications of florpyrauxifen-benzyl. Growers must follow the prescribed guidelines for using florpyrauxifen-benzyl in these cultivars and others like it.

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