Researchers identify sterility genes in hybrid rice

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This image shows heterosis and sterility of hybrid between indica and japonica subspecies. Credit: Qifa Zhang

(Phys.org)—Hybrids of many plant and animal species and subspecies are sterile, and a group of researchers in China have now identified the genes that operate to make crossbred rice sterile.

The scientists, from the National Centre of Plant Gene Research at Huazhong Agricultural University in Wuhan and the Chinese University of Hong Kong, examined two subspecies of the cultivated rice (Oryza sativa L.), japonica and indica, and identified three genes that act

together to regulate fertility in these hybrids.

Japonica is a common variety of sticky short-grain rice also known as Japanese rice, sinica or sushi rice, and indica is a non-sticky long-grain rice. Both varieties are thought to have been first domesticated in Central China around eight thousand years ago, and from there they spread throughout Asia. When crossbred the hybrids tend to be more vigorous than the parent subspecies and can yield significantly larger crops of rice.

The researchers used techniques such as gene sequencing and genotyping to analyze the genetics of hybrid indica-japonica rice in the region of a specific locus (S5) that had previously been shown to be involved in sterility in hybrids. They then compared their findings with genes in that region in other rice varieties, including Nanjing 11 (a subspecies of indica), Balilla (subspecies of japonica), and varieties producing fertile crossbred offspring: Dular and 02428.

This image shows heterosis and sterility of hybrid between indica and japonica subspecies in rice. Credit: Jiangyi Yang and Qifa Zhang

They identified three genes that contribute to the sterility in a "killer-protector" system that determines whether or not spores are formed. They found that Open Reading Frame (ORF) 5+ (killer) produces a protein that ORF 4+ influences to cause endoplasmic reticulum (ER) stress in the spore-producing cells, while a third gene, ORF 3+ (protector), produces a protein in response to the stress that counteracts it and protects the ER.

The japonica variety has a different form of the gene, ORF 3-, which means that the hybrids often carry a muted ORF gene that is unable to protect against the hybrid's more potent form of the killer ORF 5+, often resulting in premature death at the embryo-sac stage in the hybrid.

The researchers explained in their paper in *Science* that a potent combination of ORF 4+ and ORF 5+ would allow genetic differentiation of the two subspecies and prevent genes being passed on, while a potent ORF 3+ and weaker combinations of the killer genes would allow hybrids to be fertile and genes to flow to the next generation.

The findings add to the understanding of hybrid sterility, a process that restricts the flow of genes between populations, lead author Qifa Zhang said. He added that understanding the cause of the sterility may allow scientists to overcome it, and this could help in the development of more desirable and higher-yielding cultivated rice crops.

More information: A Killer-Protector System Regulates Both Hybrid Sterility and Segregation Distortion in Rice, *Science*, 14 September 2012: Vol. 337 no. 6100 pp. 1336-1340. DOI: 10.1126/science.1223702

ABSTRACT
Hybrid sterility is a major form of postzygotic reproductive isolation that

restricts gene flow between populations. Cultivated rice (Oryza sativa L.) consists of two subspecies, indica and japonica; inter-subspecific hybrids are usually sterile. We show that a killer-protector system at the S5 locus encoded by three tightly linked genes [Open Reading Frame 3 (ORF3) to ORF5] regulates fertility in indica-japonica hybrids. During female sporogenesis, the action of ORF5+ (killer) and ORF4+ (partner) causes endoplasmic reticulum (ER) stress. ORF3+ (protector) prevents ER stress and produces normal gametes, but ORF3– cannot prevent ER stress, resulting in premature programmed cell death and leads to embryo-sac abortion. Preferential transmission of ORF3+ gametes results in segregation distortion in the progeny. These results add to our understanding of differences between indica and japonica rice and may aid in rice genetic improvement.