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| <b>Title of the Application</b>                  | Methods of Increasing Outcrossing Rates in <i>Gramineae</i> (hereinafter “2020 HO Provisional”) |
| <b>Application Date</b>                          | <b>Provisional:</b> 18 August 2020  |
| <b>Application Number</b>                        | <b>Provisional:</b> 202021035587  |
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## BRIEF BACKGROUND

Heterosis (also called *hybrid vigor*) is the phenomenon in which  $F_1$  hybrids derived from diverse parents show superiority over their parents. Hybrid varieties using heterosis are popular in many crops including vegetables. Hybrid rice varieties also have remarkable strengths such as high grain yield compared to inbred rice cultivars. However, production cost of  $F_1$  hybrid seeds in rice is much higher compared to other crops because of the unfavorable rice flower structures for outcrossing. Hence, in spite of the advantages of hybrid rice varieties, hybrid cultivars seeds are more expensive compared to the seeds of inbred varieties. Enhancement of outcrossing rate is a major challenge to provide superior  $F_1$  hybrid variety seeds to rice farmers with relatively lower cost and price.

Domesticated rice is a self-pollinating (inbreeding) crop, with very low rates of outcrossing. The low rate of outcrossing causes poor hybrid seed production (seed set of ~20 %), resulting in high costs for hybrid rice seeds. One of the major reasons of low outcrossing rate in rice is

<sup>1</sup>Available at <http://books.irri.org/Approved-IPC-Policy-291017.pdf>

<sup>2</sup>Available at <https://storage.googleapis.com/cgiarorg/2018/03/CGIAR-IA-Principles.pdf>

morphological weakness of stigma (head of the pistil). To produce hybrid F<sub>1</sub> seeds, eventually the stigma of the female parents should capture pollen grains from the male donor plants for fertilization but stigma of rice is short and stays inside hull during pollination, thus limiting pollen access.

IRRI has engaged in an ambitious research project aiming at developing rice female lines with a long-exserted stigma, a desirable phenotype for high outcrossing rate. A long-exserted stigma trait was found from the wild relative of rice, *Oryza longistaminata* which favors outcrossing in nature, unlike the self-pollinating cultivated rice species *O. sativa*. Recently, the genetic element controlling the long-exserted stigma phenotype from the *O. longistaminata* genome was successfully identified through genetic analysis and was transferred to popular hybrid parental lines, using marker-assisted selection.

In initial field trials, the new parental lines exhibiting a long-exserted stigma showed a significant high outcrossing rate. Fine mapping and gene validation experiments using transgenic approaches allowed cloning the single dominant gene controlling the stigma phenotype from *O. longistaminata*.

In 2020, IRRI applied for a patent over the methods of increasing outcrossing rates in *Gramineae* through cross-based or horizontal transfer of the newly identified gene into hybrid parental lines of *Gramineae*. This patent application, [part of a patent application family](#), is expected to allow IRRI to grant non-exclusive access to public and private partners involved in hybrid rice breeding, and create incentives for additional research and development as well as investment by downstream partners.

IRRI intends to provide royalty-free licenses to NARES partners and non-exclusive commercial licenses for private companies, with a commitment to impact assessment and impact acceleration. We also ensure that our patent applications, and the patent claims, do not extend to farmers access and use of landraces per se. IRRI and its licensees will continue to comply with all obligations of the SMTA including benefit sharing, where applicable.

In addition, as per IRRI's policy, royalties paid by future licensees to IRRI shall be shared with the benefit-sharing fund of the International Treaty for Plant Genetics for Food and Agriculture, <http://www.fao.org/plant-treaty/en/>, even when monetary benefit sharing is not mandatory under the SMTA (in cases when the material continues to be available without restriction for further research and breeding).

As a non-profit international organization, IRRI promotes responsible technology transfer and intellectual property management in accordance with its Intellectual Property and Commercialization Policy (IP&C Policy)<sup>1</sup> and with the CGIAR Principles on the Management of Intellectual Assets ("IA Principles")<sup>2</sup>. This patent application conforms with the IA Principles concerning intellectual property applications in furtherance of the CGIAR Vision.

## CURRENT STATUS

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In August 2020, a provisional application was filed in India. The application focuses on the newly identified long-exserted stigma gene that significantly improves outcrossing rate in hybrid rice seed production. This invention is expected to provide rice farmers an access to superior hybrid rice seeds with lower cost. In addition, the newly identified gene may be tested for its potential effect on increased outcrossing rate in other cereal crops in the *Gramineae* family, such as wheat, through genome editing tools or plant transformation methods.

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