

Gene Flow between Cultivated and Wild Rice in Kenya

By James Kanya

Abstract

Rice is one of the most important cereal crops and is the staple food for nearly one-half of the global population (Song *et al.*, 2003). Sequencing of the rice genome has opened new opportunities for genetic improvement due to the ongoing advances in functional genomics and DNA marker-assisted selection. Thus, rice is one of the first crop species to which transgenic biotechnology has been effectively applied (Tyagi and Mohanty, 2000), although commercialisation of genetically engineered (GE) rice has not (I think it has albeit unofficially in China) begun. Many genetically engineered rice varieties such as insect resistant (Bt) rice have been developed in confined environments.

There are biosafety concerns related to the release and use of transgenic crops. The potential ecological impacts, such as pollen mediated gene flow and eventual introgression of the inserted transgenes into conventional rice varieties and wild relatives, are foremost among the concerns that need to be addressed. When transgenes escape to, and are expressed in wild relatives of transgenic crop species, they may persist and be disseminated within the wild population through sexual or vegetative propagation. If the transgenes are coding for resistance to abiotic and biotic stress such as drought, salt tolerance and diseases, established in wild populations this might significantly enhance the ecological fitness of these populations.

Transgenes may ultimately lead to problems such as invasion of novel plant types in natural ecosystems and production of aggressive weeds within agricultural fields (Ellstrand, 1985; Crawley *et al.*, 1993; Raybould and Gray, 1993; Snow and Moran, 1997). Accidental production of transgenic plants by outcrossing that have enhanced ecological fitness could perturb the natural balance in ecosystems (Song *et al.*, 2006). There is also a possibility that introduction of GM rice may lead

to contamination of conventional rice seeds resulting in varietal impurity. Further, it is contemplated that introduction of GM rice may result in the development of resistance to the unintended traits.

Pollen is the most important vehicle for the escape of transgenes, and information about pollen gene flow, defined here as the dispersal of crop genes via pollen (Rong *et al.*, 2006), is important in order to evaluate its effects. Pollination in most plant species including rice, maize (*Zea mays* L.), oil seed (*Brassica napus* L.), sugar beet (*Beta vulgaris* L.) and winter rye (*Secale cereale* L.) is affected by factors such as flowering synchronization, length of and pollen viability, isolation distance and climatic conditions (Snow *et al.* 2003; Gealy *et al.* 2003; Fuchs *et al.*, 2004; Walklate *et al.*, 2004).

Although hybridisation with some cultivated plants may reduce the fitness of wild species in natural environments (Stewart *et al.*, 2003), possible benefits of crop-wild hybridization for wild species suggest this phenomenon should not be overlooked (Boudry *et al.*, 1993; Miura and Terauchi, 2005; Campbell *et al.*, 2006). Studies of advanced-generation hybrids find that some interspecific hybrid genotypes persist for multiple generations under certain environmental conditions and therefore long-term gene introgression is possible (Lexer *et al.*, 2003; Song *et al.*, 2006).

Introgression may lead to trait combinations that enhance fecundity, competitiveness, and/or pest resistance, and these advantageous genotypes may be able to invade new habitats because of their superior fitness (Hauser *et al.*, 2003; Whitney *et al.*, 2006). The fecundity and resulting evolutionary impact of crop-wild hybrids may depend on their ability to compete with wild relatives, given that crop allele introgression will inevitably lead to populations composed of both wild and crop-wild hybrid plants (Vacher *et al.*, 2004).



In Kenya, farming systems and practices such as small scale farming, inter-village/farmer seed exchange and use of saved seeds for planting, and the occurrence of wild rice species (either use wild *Oryza* species or wild relatives of rice. Rice is not wild) would favour gene flow between conventional and GM rice fields, and between GM rice and wild related species, especially *Oryza longistaminata*. *Oryza longistaminata* is an indigenous African rice species with a genome AA similar to that of *O. sativa*, which means that hybridization between the two species is possible (Vaughan, 1994). *Oryza longistaminata* grows in wild habitats and fields adjacent to rice farms, and sometimes as a weed in rice fields, thus increasing chances of hybridization. Hybridization could potentially result in erosion of the wild *Oryza* genetic resources (Gao, 2004).

One of the ways of avoiding hybridisation between GM and conventional rice or wild relatives of rice is adequate isolation distance between the species. The isolation distance is dependent on the possible dispersal distance of the rice pollen and it is therefore important to determine the furthest distance the rice pollen grain can be dispersed.

To get information on the possible isolation distance between the GM cultivated rice (*Oryza sativa*) and conventional rice fields or wild relatives, especially *Oryza longistaminata*, we set up a study in Tana Delta Irrigation Scheme. Here, we determined the effect of distance pollen travels from a source population to pollen traps at various distances and directions. We also examined the significance of time of the day and temperature on pollen dispersal. Since no transgenic plant materials were available, due to lack of biosafety laws for handling GM materials in Kenya, non-transgenic plant materials were used as the source of pollen.

Results

Results of the study indicated that pollen dispersal decreased rapidly with increasing distance from the pollen source up to 250 m; no pollen was found at 300m. There was a significant ($P < 0.001$) difference in pollen dispersal from different directions, which correlated with the prevailing wind direction from south and occasionally from east. Wind speed and humidity had little effect on pollen dispersal distance, and there was no difference ($P > 0.05$) in pollen count between upper and lower pollen traps. Highest pollen count was observed daily between 11:00 am

and 12:00 noon, and at a narrow range of temperatures $28 \pm 20^\circ\text{C}$. On the basis of these data, an adequate isolation distance of more than 250m should



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James Kanya is a Doctorate fellow with BiosafeTrain and is a student with the University of Nairobi