KARI

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IRMA Updates

Insect Resistant Maize for Africa

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Contents

The IRMA project was launched in 1999 with the primary goal of increasing maize production and food security for African farmers through the development and deployment of improved maize varieties that provide high resistance to insects, particularly stem borers. To achieve this goal, KARI and CIMMYT scientists will identify conventional and novel sources of stem borer resistance and incorporate them into maize varieties that are well suited to Kenyan growing conditions and to farmer and consumer preferences. Major funding for the project is provided by the Novartis Foundation for Sustainable Development.

Intellectual Property Rights Report Brings Good News for the IRMA Project

As part of IRMA's commitment to making insect resistant maize a reality for the farmers of Kenya and East Africa, CIMMYT recently commissioned a study to determine whether there are any potential intellectual property (IP) rights obstacles to any future release of Bt maize in Kenya. The results of the study are now in and the news is highly encouraging.

The "freedom to operate" study of Bt maize in Kenya was performed by the Strategic World Initiative for Technology Transfer (SWIFTT), a division of the College of Agriculture and Life Sciences of Cornell University. The findings of SWIFTT's review, provided to CIMMYT in September, are quite positive. At this time, it appears that any future release of Bt maize in Kenya will be subject to considerably fewer IP restrictions than would be the case if an identical project were carried out in many other countries. While prudence may require that KARI obtain the consent of a few commercial and nonprofit entities prior to any commercialization of Bt maize in Kenya, the potential obstacles presented by IP rights of third parties appear to be quite manageable.

> ***"This is good news, indeed, for IRMA and KARI, and especially for the resource-poor farmers of Kenya," says IRMA Project Director David Hoisington.***

"This is good news, indeed, for IRMA and KARI, and especially for the resource-poor farmers of Kenya," says IRMA Project Director David Hoisington. "Bt maize holds the potential to dramatically improve the economic well-being and overall quality of life of African subsistence farmers, and do it in an

Intellectual property (IP) specialist/manager Shawn Sullivan came on board at CIMMYT in September, with start-up funding for the position provided by the Rockefeller Foundation. In addition to handling CIMMYT IP issues, Sullivan will provide guidance and backstopping for maize varieties developed by the IRMA project.

environmentally-friendly way. We still have much scientific work to do, but it looks like we are in good shape on the IP issues."

The decision to investigate possible IP restrictions was made because of the changing international landscape of intellectual property law. In many nations, it is now possible for inventors to obtain IP rights in biological materials, such as patents on genes and on processes for transforming genetic material, plant breeders' rights in germplasm, and a host of other rights created by legislation or by contract. The trend toward allowing innovators to claim IP rights in plant material is likely to continue.

Article 27 of the Agreement on Trade-Related Aspects of Intellectual Property Rights of the World Trade Organization (WTO), currently

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(Intellectual Property Rights cont'd...)

requires members of the WTO, at a minimum, to provide an effective form of IP protection for novel plant varieties. Many countries have already passed laws that exceed this minimal requirement, and others are considering doing so, because of the incentive that such exclusive rights afford for investment in the improvement of technology.

If biological materials are subject to IP rights of third parties, the consequences can be significant. Intellectual property rights, such as patents, generally give an inventor the exclusive right to sell or use his invention within a given territory for a limited time. If someone else uses or sells the invention in that territory, without the patent holder's permission, the unauthorized user or seller is guilty of infringement. Under these circumstances, the patent holder can obtain a court order forbidding further infringement and, in some cases, requiring the infringer to pay monetary damages to the patent holder. For these reasons, it is becoming increasingly important in the field of agricultural biotechnology to ensure that the release of research materials and commercial products does not inadvertently infringe on the IP rights of others.

The most common means of identifying potential IP restrictions on the use of biotechnology is to conduct a "freedom to operate" or "right to use" study of the essential components of the biotechnology product. Once the components have been identified, a search is conducted in the nations where the product is likely to be sold or used, to determine whether another party already has obtained a patent or other exclusive right to use or sell the product. Any contractual restrictions on components of the product are also taken into consideration. The results of a freedom to operate review then become a blueprint for obtaining licenses and other forms of permission that may be needed before the product is released.

—S. Sullivan

In the Lab: Bt Maize Enhances Effectiveness of Biocontrol Agent

Results from recent experiments conducted by CIMMYT entomologist David Bergvinson, on behalf of the IRMA project, indicate that Bt maize may help a tiny parasitic wasp do battle with a sporadic but devastating maize pest—the armyworm. The experiments, framed within IRMA's overall goal of cutting crop losses from insect attack, examined how Bt maize fits within an integrated pest management (IPM) strategy that includes the use of biological control agents. The IPM approach is favored and utilized to minimize environmental impact and extend the useful life of the pest management tools.

An unusual wrinkle to the research is its focus on the interaction between Bt maize and biological control agents that attack maize pests (the armyworm) that are not currently completely controlled by Bt maize. The following experiment produced a methodology to assess the impact of Bt maize on biological control agents and identifed potential synergisms between the maize and a wasp (*Campoletis sonorensis*) that attacks an armyworm species (*Spodoptera frugiperda*) that is similar to the species found in Kenya (*Spodoptera exigua*).

Experimental protocol

The experiment was conducted at CIMMYT headquarters in Mexico, where a biosafety greenhouse and laboratory are available for conducting transgenic trials. Two experimental protocols were used: (1) a "Free-choice" experiment, in which the wasps were placed inside a netting that contained both Bt and non-Bt maize infested with armyworm; and (2) a "No-choice" experiment, in which the armyworm and the parasitic wasp were either placed on maize leaves with Bt (Cry IAb toxin) or without Bt. All plants were derived from the same line (CIMMYT Maize Line 216, developed for Africa).

Free-choice study

Twelve replicates, consisting of nine Bt and nine non-Bt maize plants per replicate, were placed in CIMMYT's biosafety greenhouse, in accordance with a stratified design. The plants were covered with a nylon netting to minimize escapes. At the 6-leaf stage of development, plants were infested with 30 neonate larvae of *S. frugiperda*. Four days after infestation, 40 female wasps were introduced into the cage with 10 replacements being made each day to maintain the wasp population. Each day, a sugar solution was sprayed onto the mesh to sustain the wasps and reduce escapes.

No-choice study

The No-choice study ran parallel to the Free-choice experiment. Thirty-six small plastic boxes (25cm diameter) were prepared with three leaves from either Bt or non-Bt maize and infested with 80 neonate armyworm larvae. After four days, six wasps were introduced and given an 8-hour period for parasitism, after which, the armyworm larvae were collected for observation.

Sampling for both studies started eight hours after the wasps were introduced and continued on a daily basis for 8–14 days. Armyworm larvae were collected each day and the number and weight of the larvae were recorded. The number of wasp cocoons (signs of successful parasitism), emerging wasps, and non-parasitized larvae were recorded.

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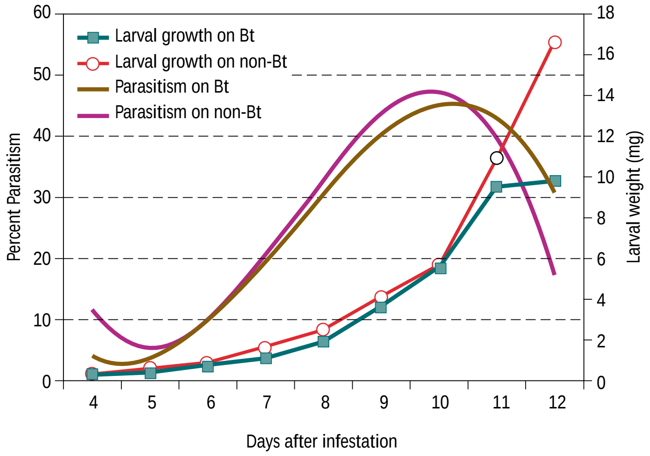
(In the Lab: Bt Maize cont'd...)

What did the experiment tell us?

The summary results from three separate Free-choice experiments are shown in the accompanying figure. First we observe that the rate of parasitism between Bt and non-Bt maize remains constant, with both maize types showing a peak rate of parasitism around 45%, attained 10 days after the armyworms were placed on the plants. Secondly, we observe that following the peak, the rate of parasitism on Bt maize is higher than for non-Bt maize, with 30% parasitism observed on day 12 versus only 20% for the non-Bt maize.

The reason for the difference is the reduced growth rate of the armyworms feeding on the Bt maize. On day 12, the average weight of the armyworms collected on Bt maize was 9.7 mg versus 16.6 mg for those on non-Bt maize.

Clearly, although the Bt maize is not directly controlling the armyworm, it does enhance the efficiency of the wasp in controlling the pest. How does this occur? Once the armyworm reaches its third larval instar, it is too large to be successfully attacked by the parasitoid. The Bt maize apparently slows the growth of armyworm, thereby giving the wasp more time to parasitize its prey. Another possible synergism emerging from this interaction is that with a reduced growth rate from feeding on Bt maize, the rate of cannibalism among the armyworms is reduced. This, in turn, means that wasp larvae already developing within a particular armyworm may have a greater probability of escaping consumption by another armyworm making a meal of its host, ultimately resulting in larger parasitoid populations. This hypothesis has not yet been tested but will be the subject of future investigation.



Results from the No-choice experiments were even more striking, but less representative of what might actually occur in the field.

With the successful completion of this study, a protocol has been established for testing the interaction between parasitic wasps and transgenic maize and quantifying the impact of the wasps on the control of secondary pests of maize, such as the armyworm. Upon construction of a biosafety greenhouse at KARI's National Agricultural Research Laboratory (NARL), similar studies will be conducted to quantify the environmental impact of Bt maize on biological controls and other nontarget organisms found in Kenya.

—D. Bergvinson

Upcoming Events for the KARI/CIMMYT IRMA Project

November will be a very busy month for IRMA staff and stakeholders, with an agenda full of meetings and workshops.

IRMA Project Annual Review and Planning Meeting 2001 – Hilton Hotel, Nairobi, Kenya, November 21-22, 2001

The second IRMA Project Annual Review and Planning meeting 2001 will be held in Nairobi, Kenya, November 21-22 2001. The first one was held in Nyeri, Kenya Dec 4-7 2000. During the meeting, each activity of the year is reviewed from reports prepared by the KARI and CIMMYT scientists within objective groups.

The specific objectives of the project are as follows:

(1) Product Development: Develop insect resistant maize varieties for the major insect pests found in Kenyan maize production systems.

(2) Product Dissemination: Establish procedures for providing insect resistant maize to resource poor farmers in Kenya.

(3) Impact Assessment: Assess the impact of insect resistant maize varieties in Kenyan agricultural systems.

(4) Technology Transfer: Transfer technologies to KARI and Kenya to develop, evaluate, disseminate, and monitor insect resistant maize varieties.

(5) Project Documentation and Communication: Plan, monitor, and document processes and achievements for dissemination to the Kenyan public and developing countries.

During the meetings, each project objective team will meet the first day when each scientist will present their activities for the year 2001 and workplans for year 2002. These will be

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discussed and the objective team leader will make summaries for presentation during the plenary in the second day.

The outputs from this years meeting are expected to be

1. Critical reviews and recommendations for the 2002 and for IRMA project as a whole;
2. Workplans for 2002 including activities, responsibilities and budgets;
3. A draft technical annual report for year 2001.

About 38 participants have been invited to attend the two-day workshop.

The KARI/CIMMYT IRMA Project Steering Committee meeting, KARI Headquarters, Kabete, Nairobi, Kenya, Friday, November 23, 2001.

The IRMA project is implemented and managed through a steering committee composed of Senior Directors from CIMMYT, KARI, and the Novartis Foundation for Sustainable Development. The Director of the Applied Biotechnology Center and Bioinformatics is the chair of the Project Steering Committee, which is composed of the CIMMYT Maize and Economics Program Directors, the KARI Director, a Ministry of Agriculture representative, and a donor representative. The Steering Committee is responsible for monitoring project performance, approving project work plans and budgets, and ensuring that all regulations and procedures are followed. This year, the steering committee will meet at KARI headquarters in Nairobi, on Friday, November 23, 2001.

The KARI/CIMMYT IRMA Project Second Stakeholders Meeting, Hilton Hotel, Nairobi, Kenya, Monday November 26, 2000

The first KARI/CIMMYT IRMA Project Stakeholders Meeting was held on March 3, 2000 at the Pan Afric Hotel in concert with the African Biotechnology Stakeholders Forum (ABSF) Stakeholders Meeting/Workshop on Biotechnology and the Media. This was also the official launch of the project. Approximately 100 stakeholders, press members, and project participants were in attendance. IRMA public awareness materials were distributed to those in attendance with special press packets distributed to members of the media. Results of the Stakeholders Meeting may be reviewed in more detail in IRMA Project Document No. 3. Grace Kimani organized the press list and every effort was made to engage the mainstream and agricultural media (print and broadcast). Substantial coverage in the print media and to a lesser extent the broadcast media resulted.

Stakeholders gave a resounding nod to the project to introduce Bt maize into Kenya, provided that the national rules and regulations governing GMOs are followed.

During that meeting, stakeholders asked to be informed on the progress of the project. We have done this through coverage in the media as well as publications. It is now time for stakeholders to come together again to review the progress as well as give feedback on the way forward to the project scientists.

The Second IRMA Stakeholders Meeting will be held in the Hilton Hotel, Nairobi, Kenya, on Monday, November 26, 2001, starting at 1.45 pm. Invited participants from outside Nairobi will arrive on the morning of Monday, November 26 and will be accommodated on a bed and breakfast basis at the Hilton Hotel Nairobi. Registration will be at the Hotel at 11.00 a.m.–1.45 p.m. A cocktail will be served after the meeting.

Training Workshop On Enhancing Scientists' Communication With The Mass Media, ICRAF – Gigiri, Nairobi, November 27–29, 2001

The African Biotechnology Stakeholders Forum (ABSF), CIMMYT, USDA, and the Rockefeller Foundation have organized this workshop with funding from USDA. The theme is "Enhancing Scientists' Communication with the Mass Media."

Sessions will include training by a psychologist on the basic communication model, and evaluating communication skills (by Dr. Helgo from South Africa). Prof. Klaus Leisinger, of Novartis Foundation for Sustainable Development, will present a session on "Facing the Press." Dr. David Hoisington will present "Basics of Biotechnology."

A Panel Discussion/Forum with Q & A will be held with panel members presenting what they consider to be the (1) benefits of biotechnology for developing world agriculture, (2) the legitimate issues surrounding its use, and (3) bogus issues raised about its use. After all present, the floor will be open to questions from journalists and scientists. The panel will include Klaus Leisinger, David Hoisington, a representative from the USDA Agricultural Research Service, Jürg Bürgi (a European journalist), and Florence Wambugu.

Other sessions include: "Communication Lessons Learned the Hard Way," presented by Kinyua M'Mbijjewe of Monsanto; an Introduction to Writing Newspaper Articles, Press Releases, and Letters to the Editor by David Poland of CIMMYT; Science Writing vs. Standard Reporting" by Jurg Burgi; and Reporting on Biotechnology: Trials and Tribulations" by Barrack Gogo of Picasso Productions.

Exercises will include scientists producing releases on their own work and journalists interviewing scientists.

A total of 50 trainees from West and East African countries and 10 resource persons, mainly from the organizing institutions, will gather for the workshop. About 10 scientists from CIMMYT and KARI, who are involved in IRMA project activities, will take part either as resource persons or as participants.

—S. Mugo

Guiding Technology Development through a GIS-based Ex Ante Impact Assessment Model: the Case of Insect Resistant Maize in Kenya

Determining the allocation of funds for developing pest management technologies in developing countries is a complex process. Impact assessment usually only takes place after the end of the project and, since crop loss assessment is complicated and expensive, it is rarely systematically applied.

IRMA and ICIPE scientists recently produced a paper on a practical tool that saves costs by combining geo-referenced data from different sources and disciplines to estimate the impact of different interventions, applied, in this instance, to estimate the potential impact of developing insect resistant maize in Kenya. Specific to the approach is its interdisciplinary nature, in particular, the participation of economists from the start of the project.

The basic model calculates the economic value of crop losses due to stem borers, for different species and for different agroecological zones in Kenya. The data include farmers' perception of losses, direct measurement of losses, agroecological information from six zones that is specific to maize production, the distribution of different stem borers, the effectiveness of different Bt genes, population data, maize production data, adoption levels of improved maize varieties, and maize prices.

On average, Kenya produces 2.6 million tons of maize annually. Total losses from stem borers, derived from direct measurements, are estimated at 14 % (valued at US$ 85 million), ranging from 11% in the highlands to 21% in the dry areas. Almost half of the losses (US$ 40 million) occur in the moist transitional zone. This area also has a high adoption rate of improved varieties (95%), making it a promising target area. In the dry areas, losses are relatively high (21%), but low yields there reduce potential benefits. For open pollinated varieties (OPVs), however, these benefits would be distributed fairly evenly over the populations of these marginal areas, making a significant difference to their food security.

Only four stem borer species inflict crop losses above 10% in at least one region, and only two species are of major economic importance: *Busseola fusca* (81% of all stem borer losses in Kenya) and *Chilo partellus* (16%). Based on the value of the losses, the highest benefits can be expected from breeding varieties resistant to *B. fusca* for the moist transitional and highland tropics ($27 and $21 million in annual losses, respectively), followed by breeding for resistance to *C. partellus* for the moist transitional ($10 million), the dry areas ($8 million), and the moist midaltitude areas ($5 million). Except for the highlands and the lowlands, developing combined resistance to both species is indicated. Since bioassays of Bt genes have found very efficient genes against *C. partellus* but not against *B. fusca*, the search for Bt genes that are effective against *B. fusca* is likely to result in high benefits.

The results show how the model can incorporate information from different sources to guide research and data collection to the areas with the highest return on investment. Because maize is the dominant food crop in Kenya and much of Africa, and stem borers are its major field pests, these results have immediate implications. With minor modifications, the approach can also be used for other pest management control techniques, such as biological control, and for other pests such as *Striga*.

—H. De Groote, W. Overholt, L. Macopiyo, S. Mugo

Do you have a question or comment about the IRMA project or the quarterly newsletter articles? Or perhaps you have an article you would like to contribute. If so, please contact the IRMA Quarterly Newsletter editor at d.poland@cgiar.org or IRMA Coordinator Stephen Mugo (contact information on this page).

Shooting Tape of Shooting the Gene Gun

In the latter half of September, a two-man film crew from Nairobi, Kenya traveled to CIMMYT headquarters to see and record the processes involved with genetic engineering (transformation). Once segments are packaged into a broadcast format, the video pieces will be used to inform and educate people in Kenya and sub-Saharan Africa about the science behind transgenic plants, particularly maize.

"The CIMMYT trip was a great opportunity for us to get some footage showing what is actually involved in biotechnology—the real nuts and bolts—as well as some clear explanations about the work" says Barack Gogo, Producer/Director for Picasso Productions, who headed up the film crew.

"For instance, I'd never seen a gene gun in operation before, though we've produced a lot of stories on biotechnology. Just the term—gene gun—conjures up a lot of negative science fiction images about the technology. Hopefully when people see what is actually involved in making transgenic plants, it will keep their imaginations from running wild and bring discussions about the issue back down to earth."

While at CIMMYT, Gogo and his cameraman taped interviews with Dr. David Hoisington, Director of CIMMYT's Applied Biotechnology Center and IRMA Project Director; Allesandro Pellegrineschi, cell biologist; Scott McLean, geneticist/breeder; Enrico Perrotti, molecular biologist; Julien Berthaud, population geneticist; and others. Field and lab shoots included the biolistic transformation process (the gene gun that inserts new genes into crop plants), the screening process to find successful transformants, the biosafety greenhouses, maize and its wild relatives (teosinte and *Tripsacum*), and general background shots to present maize in the context of Mexico, the center of diversity and domestication of the plant.

"We're hopeful about getting some of this information out over the airwaves in Kenya as well as Africa generally," says David Poland, who works on IRMA's communication component. "Public awareness is an important underlying principle of the IRMA project. That means going beyond slogans and posturing to really putting information about the project and the technologies out there.

"With IRMA," he continues, "we hope to produce a range of informational materials to reach diverse audiences in the most effective manner. In other words, we'll produce everything from highly technical journal articles aimed at the scientific community, to a quarterly newsletter for project staff and stakeholders, to simplified posters that extension can use in discussing insect resistance with farmers. The interviews and taping by the film crew are a part of this overall effort.

In addition to promoting some of the segments for broadcast on Kenyan television and elsewhere in Africa, the interviews served as the basis for several print stories that were published in Biosafety News, a monthly newspaper focused on biotechnology developments in Africa. Picasso Productions will also conduct several sessions at an upcoming workshop on training scientists to work with the media, to be held in late November in Nairobi.

—D. Poland

Julien Berthaud, a population geneticist with CIMMYT-IRD, explains the possibilities of gene flow between maize and its wild relative teocinte to Barack Gogo of Picasso Productions.

Farmer-Oriented Research in Western Kenya

Participatory rural appraisals (PRAs), conducted by KARI and CIMMYT economists, provide the IRMA project with essential information about farmers' wants, needs, capabilities, and constraints related to maize production and farming generally. Under IRMA, PRAs have been conducted at more than 40 sites throughout Kenya's five agroecological zones, with more than 900 male and female farmers participating. Following is a typical, but abbreviated, report on one such PRA.

Bulemia village is situated in Butula Division of Busia District in Western Kenya. The village is about 3 km from Butula administrative headquarters, on Mumias-Bumala road. Agriculture, dominated by mixed farming, is the mainstay of the rural folk in this village. The main crops are cassava, maize, sorghum, sweet potatoes, finger millet, bananas, and sugarcane, while livestock is composed of mainly cattle, poultry, and goats. Cassava has been the main food crop in the village since time immemorial. However, outbreaks of cassava mosaic virus have devastated production of the crop, so maize, sorghum, and sweet potato are becoming the major crops.

A participatory rural appraisal (PRA) was conducted in Bulemia village on July 12, 2000, the objective of which was to determine which maize varieties farmers grow, farmers' preferences in choice of the varieties, and to evaluate farmers' perceptions about maize farming. The PRAs are to be used by KARI, CIMMYT, and the IRMA project to formulate farmer-oriented maize research.

Word was sent to the village to announce and publicize a meeting (baraza) between KARI and CIMMYT researchers and the local extension agents and farmers. Seventeen men and 20 women attended the meeting on their own volition. About 75% of the farmers in attendance grew predominantly local varieties, especially a white-grained variety called:"*Ke-Buganda,*" in apparent reference to the source of the seed. The variety is imported from Uganda. Most farmers prefer the variety because it yields reasonably well, even under low soil fertility levels.

Sipindi (derived from the local word for speed), a yellow-grained local variety, is often preferred because of its early maturity and tolerance to *Striga*, drought, and insect pests. As farmers remarked, "although short rains in this area are unreliable and the adverse effects of *Striga* and stem borer are high, we are sure to obtain some harvest when we plant this yellow maize, unlike your hybrids. Here, we are poor and we rarely apply chemical fertilizers and pesticides in maize fields." The farmers indicated that they preferred improved maize varieties that yield reasonably under low crop management levels and called upon the government to ensure that maize seed in the market is not adulterated.

One of 900 farmers who participated in the IRMA PRAs displays yellow and white maize varieties. In the village of Bulemia, both a white and a yellow variety found widespread acceptance. The white variety, Ke-Buganda, was favored for its relatively good yields under low soil fertility, while the yellow variety, Sipindi, gained accpetance based on its early maturity and resistance to drought, *Striga*, and insect pests.

Bulemia Village:

Physical environment:

- Climate: Moist midaltitude
- Rainfall: 1200 mm/year
- Temperature: 12-24 ^{0}C
- Soils: Varied, but mainly clay-loam and sandy loam, some areas have lateritic horizons.
- Vegetation: Mainly artificially established

Socioeconomic aspects:

- Inhabitants: Marachi sub-tribe of the Luhya tribe that occupies western province of Kenya. The majority understand the Luo language, as the village borders Siaya District, which is dominated by the Luo tribe.
- Infrastructure: The village is dissected by an earth road, which is often impassable during heavy rainy season. Public telephone and health services are available within 3 km. A rural market is located within the village.
- Agriculture is the main economic activity.
- The main constraints to agricultural growth and development were identified as:
    - Low soil fertility
    - Poor cash flows
    - Poor knowledge of agricultural practices
    - *Striga* infestation
    - Stem borer infestation
    - Unreliable rainfall

— M. Odendo

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