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Advancing the Understanding of Biosafety

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Lecture

Transgene Flow in Small-Scale Systems -

Ghana as Model

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To allow for a fuller consideration on the implications of GMOs in developing countries relative to the developed country context, this paper will present an account of a project that assessed the implications of GMOs in small-scale agricultural systems in Africa by focusing on a specific sector of agricultural food production in Ghana. Maize cultivation has been used in this instance to distinguish the differences that exist between agriculture in the US or Europe, and elsewhere in other developed countries and those of the African conditions. In particular, looking at the agricultural structure, the landscape, crop field locations, isolation distances and spatial patterns of agricultural fields which are completely heterogeneous. On the basis of a modelling approach, representative scenarios are calculated to address the possible impacts of gene flow between GM and conventional fields due to cross-pollination. An extension into the topic will be made to gain an understanding from the perspectives of the farmers themselves, which seed sources and factors they consider most relevant or useful in terms of accessibility to seeds, agricultural productivity and economic considerations? These data are highly relevant to the Biosafety discussion because of the urgent need for a scientifically acceptable and applicable guidance on small-scale monitoring of GMOs. Particularly, the need for the identification of suitable test parameters to assess gene flow for the receiving environments. This study aimed to bridge the gaps by developing appropriate sampling methods for estimating potential impacts of gene flow due to the introduction of GMOs in small scale systems. So far, large scale data on the ecological impacts of GMOs in small scale agricultural systems are still very limited. This paper will address the topic in two distinct parts. First, it will provide data on the location and general field geometries, as well as the isolation distances of the prevailing cropping conditions. Basing, on these data, further calculate for gene flow estimates within sown conventional maize due to the introduction of GM crops. Thirdly, the paper will discuss possible socioeconomic impacts on farmer livelihoods and assess implications for seed diversity as well as the biosafety implications. These are of utmost relevance for Ghana since the Seed Bill, which addresses seed use, exchange and distribution is presently before parliament for consideration alongside the Biosafety Bill, yet to come into force. The Seed Bill was reviewed to include biotechnology and the consideration of genetically modified crops (GMOs). Amendments are being made to ensure not only the protection of the environment and genetic diversity of landraces but also health issues including food safety relative to seed distribution due to the introduction and use of GMOs in the country. Also of great concern is that in Ghana, nearly seventy percent of agriculture in is carried out under the smallholder context, and over 90 per cent of Ghanaian farmers rely on saved seeds from previous harvests or exchanged for their annually sown crops, rather than through purchase of certified seeds. Furthermore, maize serves as the basic food necessity for the greater part of its population in the country. On the one hand, GM maize is advertised by the developers to serve an added value by improving upon weed management and a reduction in costs and amount of herbicides applied to field crops. Resistance to insect pest attack is additionally an alternative trait promoted by the developers.

Therefore, to strengthen the understanding of Biosafety, it is important for all stakeholders, decision and policy-makers to consider from a scientific perspective- Whether seed segregation or trait traceability is feasible following the introduction of GMO into small scale agriculture taking into account the Ghanaian agricultural, social and environmental conditions? Gene flow is discussed in this context. Gene flow is a relevant ecological process, but the effects which it may have must be fully assessed. For a complete risk assessment, this is required in accordance with the Cartagena Protocol on Biosafety (2000). Gene flow incorporates genes into the gene pool of one population from one or several populations, eventually determining the genetic structure of natural populations. Dispersal of seeds and pollen are important mechanisms leading to gene flow in plant populations. In the context of GMOs, concerns have been raised over possible agronomic and environmental impacts. Agronomic impacts could result from the incorporation of transgenes from GM crops into native crop species with potential adverse effects for the conservation of landraces and plant breeding. Some environmental effects relate to impacts on non-target insect species or herbicide resistance leading to persistence or invasiveness of species. The economic value to GM growers or of hybrids due to transgenes in conventional harvests is highly uncertain. Again, the potential loss of farmer livelihood and seed security is an additional concern.

Methods

A Global Positioning System (GPS) receiver was used to determine maize cultivation locations. Data collected were systematized in a database and field acreages calculated based on their geometries that were estimated using GIS software. A quantitative model was applied to estimate gene flow through representative scenarios of actual field practices in a 20 km^2 area. Subsequently, cross-pollination rates between GM fields and conventional fields were calculated. Questionnaire surveys were conducted with about 200 farmers to evaluate the extent of seed acquisition sources and their preferences, examining also the socioeconomic conditions of the smallholders.

Analysis and conclusions

Traceability ensures quality control in seed supply systems. The data indicates that once GM products are introduced, traceability of GMOs would be very difficult in case adverse impacts eventually emerge. Secondly, the very small nature of fields and their close proximity would not allow for the implementation of isolation distances between GM and conventional fields as a management strategy. This poses a high probability for transgene contamination of local seed varieties as a potential consequence. Thirdly, the large number of smaller fields suggests a larger number of potentially different seed varieties being sown by smallholders potentially leading to increased genetic exchange and genetic variability. Cultivation of GM maize will come with a high probability of impacting on the seed landraces and genetic diversity including areas where conventional farming is likely practiced. Forth, the highly informal nature of the small-scale agriculture or open space farming in backyards or on marginal spaces already makes it very difficult to regulate the cropping situation and agricultural markets, including any GM seeds that may be introduced in the future. These conditions only pose a major difficulty since options that would allow for consumer choice and trait segregation is substantially less. Therefore, the containment of GM products including mitigation or removal from the environment would require very heavy investments and political commitment to implement. The use of isolation distances as a management requirement to control gene flow between GM and conventional fields is challenged. An estimated 98% of all fields numbering about 1,300 documented for the study area had a maximum of 3, 4, 5, 7 and 8 field neighbors at distances of 20 m, 40 m, 60 m, 80 m and 100 m respectively. With a minimum nearest neighbour distance of 5 m and a maximum nearest distance of 459 m, the practice of co-existence of GM and conventional cropping would not possible. In terms of field sizes, nearly 98% of all fields encountered occurred below 0.5 Ha in size, with the remaining 2% ranging between 0.5 to 2 Ha and above. On-farm conservation of maize genetic resources would be unlikely due to higher cross-pollination in smaller and adjacent fields as indicated by the model. The size of a recipient field, its location and the distance to a GM field proved to be very important parameters to estimate the probability of transgene introgression. The assessment allowed testing potential cross-pollination rates even for a single GM field as the most minimal scenario, which turned out to be unfavourable with a conclusion that with an introduction of GMO, areas cropped to conventional agriculture will gradually be impacted by GMO and will potentially increase across the landscape.

In relation to seed use, seeds sown by farmers are obtained from a wide range of sources. The use of food grains as seed grains was most significant, and often not distinguishable as such. However, seeds from previous harvests are also crucially relevant source. Farmers confirmed that the varieties sown are mostly landraces with the argument that they provide economic advantage due to saving on cost of acquiring certified seeds. Seeds that were sown from previous harvests are significant and largely influenced by the availability financial resources. Thus, the growing of GM crops could pose additional difficulties to the farmers. In particular through the payment of technology fees that could be an economic threat to the security of farmer livelihoods. The model confirmed that for a single GM field for example, comprising 0.2% of conventional cropping area could potentially lead to gene flow in the considered region up to 0.12% of transgenes in harvested crops. This data indicated that very small fractions of transgene introgression in the order of magnitude of up to 2.61% in conventional fields are possible under the various tested conditions. In comparison to the EU regulatory standards for GM labeling threshold of 0.9%, any increasing condition of transgene presence in conventional harvests from any magnitude above 0.9% is sufficient to be labeled, considered or sold as GM. For the African conditions, the consequences would be immense. In the first place, it will limit the potential to expand on agricultural food exports and deepen existing trade blocks between the continent and the developed nation counterparts. The study showed that local farmers would have a difficulty to differentiate between conventional and GM at the smallholder level which introduces a further complexity. With the introduction of GMOs, area cropped to GM would most likely increase over time due to transgene flow into conventional fields and further exacerbate the impacts. In conclusion, it is important to note that the agro structure and seed exchange practices would make it possible that gene flow even at low frequencies may easily be detected in conventional production, possibly with legal repercussions for the small farmers if patent infringement clauses are applied by the developers. It is also worthy to note that the usefulness of isolation distances under the described conditions is challenged. Finally, with the introduction of GM, on-farm conservation of conventional seeds would be very unlikely due to increasing content of GM traits in farm-saved seeds. The implications of this outcome seem to be an issue and should therefore be an issue for further discussions.

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