

Is Bt maize effective in improving South African smallholder agriculture?

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There is intense debate about the role of genetically modified (GM) food crops in combatting low yields and food insecurity amongst smallholders in Africa. Bt maize is still the only commercialised GM food crop in Africa and thus provides an unique opportunity for an empirical evaluation on this matter. South Africa is the only country in Africa where farmers grow Bt maize. South African smallholders have been introduced to Bt maize through a number of private enterprise interventions and government programmes since 2001. Scientific publications on the effects of Bt maize on South African smallholders, from socioeconomic and ecological perspectives, are now starting to accumulate.¹⁻⁴

Bt maize produces insecticidal proteins that provide resistance to the African maize stem borer (*Busseola fusca*) and the Chilo borer (*Chilo partellus*) which can cause significant yield losses in low-input African smallholder systems.⁵ As maize is the dominant staple crop in Africa, and stem borer damage is a significant production problem to many African smallholders, Bt maize could have substantial positive impacts on the livelihoods and food security of smallholders. In this commentary, we argue, however, that the fact that Bt maize was originally developed for use in large-scale capital intensive farming is still reflected in its functioning, which currently results in it being of limited use to smallholders. In addition, the regulatory context in which Bt maize was introduced in South Africa, and the lack of information provided to smallholders with the introduction of Bt maize, further reduce the current possibility of smallholders benefitting from it. As an alternative, we see positive progress in public-private initiatives to develop new maize varieties, specifically for smallholders' preferences and circumstances, which, we argue, show greater potential to improve food security in smallholders' contexts.

The first aspect which negatively impacts on the possibility of Bt maize to be of benefit to smallholders is the economic risk that its adoption entails. To date, Bt maize seed has been supplied to smallholders through government-sponsored interventions – either for free or at greatly subsidised rates; smallholders therefore have not yet experienced the real costs of the seed. Bt maize is currently sold at about double the price of popular non-GM hybrids and five times that of the price of popular open pollinated varieties (OPVs). Despite the high prices, some economic studies on Bt maize have reported that, by averaging over a number of years, smallholders can benefit from adopting Bt maize compared with planting conventional hybrids.^{2,6,7} However, stem borer pressure is highly variable between seasons⁸; therefore during years and at sites that experience low insect pressure, the economic benefit of planting Bt maize can be negative.⁷ Resource-constrained smallholders who do not have an economic buffer are not able to absorb losses in years for which the cost of Bt maize seed does not pay off.

Further reinforcing economic risk taking, currently commercialised Bt maize varieties are developed to give high yields under good agricultural conditions (sufficient and timely rain, fertilisation and good storage conditions). Smallholders often do not have the economy to provide such an optimal farm environment, and commonly farm on lands that are less suited for agriculture. As a result, planting currently available varieties of Bt maize entails the risk that input costs will not be covered within any one year. Indeed, studies on Bt maize in South Africa indicate that commercial varieties into which the Bt trait is introduced are outperformed by locally used non-GM hybrids and OPVs, which are better adapted to smallholders' agro-ecologies, fluctuations in rainfall and suboptimal storage conditions.^{1,2}

Other countries, such as India, China and Argentina, which report higher adoption of Bt crops by smallholders, have less monopolistic seed markets and lower prices for GM seed than South Africa does, and, as a result of lower regulatory control on GM crops, the Bt traits have also to a greater extent been incorporated into locally suited varieties. It must also be noted, however, that the lower regulatory control of GM crops in these countries has simultaneously led to the marketing of seed of dubious quality, which negatively affects farmers.⁹⁻¹¹

Lack of transfer of information on Bt maize is found to be a key obstacle for successful adoption by smallholders. To successfully adopt Bt maize, farmers must be informed that it provides resistance to stem borers; and, for the sake of preserving the stem borer resistance, they need to be taught to plant a refuge of non-Bt maize next to their Bt crop. This refuge is provided by planting a specified area of non-Bt hybrids with the Bt crop, thereby providing feeding grounds for stem borers. In South Africa today, the main information channel on Bt crops to smallholders is through the private sector (seed companies and local seed retailers). Jacobson and Myhr¹² reported from the Eastern Cape Province that the information days on GM crops held by seed companies were insufficient for transferring all the necessary information and that the local seed retailers largely lacked the ability to transfer information on GM crops. We have recently (in September 2014) witnessed a similar situation in the Limpopo Province where Bt and Roundup Ready maize is about to be rolled out to smallholders through a government-funded programme, while seed retailers and local government authorities lack sufficient information on GM crops. Research shows that as a result of the current flaws in how information on Bt maize is transferred to smallholders, many smallholders planting Bt maize are not fully aware of what makes it different from other hybrid maize^{12,13}; and they often do not understand the purpose of refugia, nor comply with the demand to plant them.¹² (To some extent, the lack of compliance with refugia plantings also applies to large commercial South African farmers.^{14,15})

Regulations regarding Bt maize in South Africa also currently obstruct smallholders from fully benefitting. These regulations apply both to the patents for GM crops and the biosafety management practices that come with planting GM crops in South Africa. Both forms of regulation result in farmers not being allowed to recycle GM seed. While hybrid seed in general is unsuitable for recycling because of yield drop, resource-constrained smallholders

frequently use the possibility of recycling seed to be able to plant in years for which the budget does not allow for the purchase of new seed.¹²

In summary, current Bt maize varieties in South Africa are expensive, are not suited to planting in suboptimal agricultural environments and come with regulations that smallholders do not understand or with which they do not agree. Whilst some of these problems can be remedied, there are cheaper alternatives available that are more attuned both to smallholders' agro-ecologies and to their farming practices.

The South African government is currently, through the Agricultural Research Council – Grain Crops Institute (ARC-GCI), promoting the development and certification of maize OPVs suited to smallholder conditions and practices. The ARC-GCI is working in collaboration with the International Wheat and Maize Improvement Center (CIMMYT), initially through the Southern African Drought and Low Soil Fertility Project, and now through a breeding programme called Drought Tolerant Maize for Africa. These initiatives are working closely with smallholders and have resulted in the registration of a number of stress-tolerant maize OPVs on the South African Variety List. In addition to drought and low soil nitrogen tolerance, the varieties also possess such desirable traits as resistance to major maize diseases (e.g. turicum leaf blight and grey leaf spot), superior tolerance to smallholders' storage conditions, early maturation and suitability for home processing.^{16,17} These are features of maize that are repeatedly highlighted as important by smallholders in southern Africa.^{16,18,19} As a consequence of the projected increase in moisture stress because of climate change, these varieties, and continued efforts to produce them, can also be expected to substantially contribute to food security in future. Smallholder farmers in the Limpopo Province have already adopted some of these varieties, and are currently growing and marketing certified seed of ZM 1421, ZM 1521 and ZM 1523. In the Eastern Cape Province, some of the OPVs showed very stable performance across different stress-prone environments and seasons, and produced yields that were not significantly different from hybrids.¹⁸ Zero seed costs can be realised for some seasons, because of the option of recycling seed of OPVs without the yield penalty associated with recycling hybrids.

We argue that government money would be better spent on supporting further development and spread of these less costly stress-tolerant maize OPVs to smallholders which, we argue, have better prospects for increasing and stabilising smallholders' maize yields in economically sustainable ways.

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