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Genetically engineered food crop resistance to pests typically enhances yields in sub-Saharan Africa

Summary

We investigated the yield implications of genetically engineered (GE) food crop resistance to pests and diseases under infestation in confined field trial and farm settings across sub-Saharan Africa. A rapid evidence synthesis revealed that GE food crops typically increased resistance to pests/diseases and the majority of these increases were significant. GE crops with enhanced resistance to pests/diseases typically resulted in enhanced yields compared to their controls under infestation. However, only a small number of studies reported effects on yield, and not all studies reported a positive relationship. More yield data is needed from field trials and farm settings to fully understand the benefits of genetically engineered resistance to pests/diseases in sub-Saharan Africa.

Recommendations for policy

- **Evaluate the benefits of genetically engineered crops:** Policy makers should be aware of the range of potential benefits for yield and pest/disease control surrounding genetically engineered crops – those that wish to explore alternative pest/disease management practices that reduce the use of pesticides may wish to consider confined field trials of genetically engineered crops for countries where this is not already ongoing.
- **Consider factors that might limit these benefits:** Policies aimed at maximising crop yield need to reflect multiple environmental factors that may limit yield potential of GE crops in target agro-ecosystems.
- **Standardised field trials:** More standardised procedures for confined field trials are needed (ie uniform infestation application, measurement of pest/disease incidence, yield measurements) to clarify the extent to which GE crop resistance influences yield across different studies.
- **More field trials:** To supplement the currently limited evidence base, more African countries need to permit confined field trials in their biosafety policies (currently 13 out of 54 African countries have approved confined field trials).

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The challenge

Food security in sub-Saharan Africa (SSA), which is adversely affected by agricultural yield losses from pests and diseases (USD 6Bn, 2005-15)[1,2] will require significant intervention to meet the needs of its growing population (2.1Bn by 2050)[3]. The use of genetically engineered (GE) food crop resistance to pests and diseases is one method that is proposed to have significant impact[4]. Confined field trials on ten GE food crops are currently ongoing in nine countries in SSA to validate their robustness[5]. Alongside health, environment and socio-economic factors, evidence of GE crop field efficacy against pests/diseases is essential for informing policymakers to aid decision-making as to their adoption and commercialization[5]. Syntheses of the studies on the efficacy of GE crops under controlled laboratory conditions exist[6]. However, none have synthesised the extent to which GE crop resistance to pests and diseases may benefit yield in fields/farms across SSA. We addressed this by performing a rapid literature synthesis.

The method

Literature search and selection: A rapid systematic search revealed 914 studies from Web of Science and 310 studies from Google Scholar. These studies were filtered for duplicates (N=29), screened by title (N=96) and by abstract (N=24), which were screened at full text to meet the following criteria: 1) Any type of food crop; 2) Genetically engineered by any method; for 3) Resistance to any type of pest or disease (versus non-GE control crops); 4) Grown in field or farm sites; in 5) Any country in sub-Saharan Africa (N=12)[7–18]. From these, 24 field trials were selected and within each, data from all independent lines modified in the same gene were combined, unless specified.

Critical appraisal: Full text papers were subjected to a value judgement on whether: 1) Causal relations were well supported; 2) Outcomes were measured in the appropriate way and 3) There was any evidence of selective reporting.

Analysis: Study outcomes extracted from full-text papers were: 1) Resistance to pests or diseases and 2) Subsequent yield under infestation (if reported) in GE crops compared to non-GE control crops, to calculate fold change effects by GE. Fold changes were assigned Effect Sizes and Confidences were determined from sample sizes of field trials.

The results

Despite the scarcity of published studies on GE crop resistance to pests and diseases conducted in confined field sites in sub-Saharan Africa, those selected revealed two key findings:

1. GE crops had a large variation in enhanced resistance to pests and diseases, ranging from small effects to almost complete immunity. All GE crops had significantly increased resistance to pest/diseases, with the exception of 4/24 field trials. These were from two studies[7,8], which found no effect of GE maize on resistance to stem/stalk borers in: (i) *Busseola fusca* and *Chilo partellus* (in terms of egg batches laid)[7] and (ii) *B. fusca* and *Eldana saccharina* (in terms of detached leaf area consumed)[8]. In studies that used the same Bt maize line, field resistance (in terms of on-plant damage) to *C. partellus*[9] and *B. fusca*[10] was observed. Together, these indicate that different field trials with different measures of resistance, using GE lines modified in the same gene, may report different levels of resistance.
2. Where yield was reported (13/24 field trials), GE crop resistance to pests/diseases typically resulted in enhanced yields (11/13 field trials, 7/11 were significant). Non-significant differences in yield may be attributed to low sample size[12], or site-to-site variation in growth conditions, such as use of irrigation in the later-than-usual growing season and pesticide, lessening the deleterious effect of infestation on the growth of non-GE crops[13]. The negative effect of GE on yield (1/13 field trials) may be attributed to a growth-stunting effect by GE[11]. It must be noted that a large number of studies reporting GE crop resistance did not report differences in yield, making yield implications from these studies far less certain.

More information

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