Harnessing nature in Africa

Biological pest control can benefit the pocket, health and the environment.

Peter Neuenschwander

In Africa, swarms of desert locusts are threatening crops from the Atlantic to the Red Sea, and 12 million hectares of often fragile environments have been treated with insecticides. This is worrying, as the last major swarms in 1988 took several years, 1.5 million litres of chemical pesticides and US$300 million to bring under control. Since then, ecologists, economists and politicians concerned about the effects of these pesticides on human health and the environment have agreed that alternative methods were needed to combat locust outbreaks — ideally before the locusts invade agricultural land in the Sahel region.

Such methods would replace chemicals with biological alternatives that are environmentally friendly and economically viable. After 15 years of work by an international collaboration (which includes my institute), a new biopesticide based on fungal spores, Green Muscle, has been licensed for use against grasshoppers and locusts in many African countries[1]. It has been successful in field trials against grasshoppers in West Africa and is well received by farmers, but has not yet been widely deployed. Part of the problem is the relatively slow action and perceived high cost of Green Muscle. But the biggest hurdles are regulatory and the perception that biological control — whether in a crisis or for everyday use — is not a true alternative to synthetic pesticides.

The 'green revolution' of the 1960s and 1970s introduced high-yielding crop varieties, which flourished when combined with synthetic pesticides and high doses of fertilizer. This resulted in an increase in agricultural production in Asia and South America, but Africa did not benefit to the same degree. Since then, large-scale programmes for breeding pest-resistant, high-yielding 'improved' varieties that do not depend on high quantities of fertilizer or insecticide have brought considerable benefits to Africa[2], with estimated productivity gains of US$335 million for cassava (West and Central Africa alone) and US$1.33 billion for maize. Improved plant resistance remains the most important tool in the fight against viruses, bacteria, fungi and nematodes, and is one of the four pillars of integrated pest management (IPM). The other three are biological, chemical and cultural (such as ploughing, weeding and mulching) control.

Improved crop varieties can provide a complete solution, at least temporarily, when used in conjunction with good soil management. By keeping pest populations at a minimum, they reduce the likelihood that pests will overcome plant resistance mechanisms and prevent other potential pests from becoming a serious threat. But developing and then getting producers to use improved varieties and new farming practices is a slow and painstaking exercise.

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Looking for solutions: biopesticides could prevent locust swarms.

New pesticides, when integrated into a sound IPM system, are less harmful than old products, but most African farmers cannot afford them. Instead they use cheaper (sometimes obsolete) chemicals — some of them banned in Europe and North America. Consequently, misuse of synthetic chemicals is rampant, causing well documented health and pollution problems, particularly on cowpea and stored maize.

Battle of the beasts

It is time to consider other options that offer economic and environmental benefits. With foreign species invading Africa at an increasing rate and threatening agriculture and conservation, we argue that biological control, particularly against insects, mites and weeds, should receive more attention. Classical biological control consists of the introduction, establishment and spread of specific natural enemies against exotic pests. Proponents of this approach are sometimes accused of being 'green dreamers', who want to keep poor farmers poor. But the data in Table 1 demonstrate that even if you consider the impact of these biological control technologies in terms of their yield only — without taking into account the environmental impact — they offer benefits comparable to those of the long-term plant-breeding programmes for cassava and maize[2]. A closer look at the strengths, weaknesses and ecological context of biological control is needed.

Before they invaded Africa, some exotic pests, such as the two mealybugs, were not even known in their native countries. By contrast, water hyacinth and other water weeds, which impede fishing and traffic (including transport of agricultural produce), are also pests in their homelands. The benefit:cost ratios for these biological control projects are astonishingly high, far above 100. The successes in Table 1 have been evaluated using modern economic models, taking into account depreciation (6–10%, depending on the project). Cassava green mite, mango mealybug and water hyacinth are now controlled with minimal additional costs in many other countries. Many more examples of successful biological control (but without corresponding economic evaluation) have been documented across Africa, for practically all crops[3].

This type of pest control has a unique advantage: it is self-regulating. Unlike resistant crop varieties, biological control pits pests against their natural enemies. In a continuous arms race, these parasitoids and predators counteract any emerging defence mechanisms, thus assuring that biological control does not break down. When 'resurgences' of previously well controlled insects occur, these are most often attributable to synthetic insecticides applied against other targets, which have killed exotic and indigenous natural enemies indiscriminately. In the past, some biological control agents had unfortunate effects on non-target populations, but today such problems are rare[4], despite claims to the contrary. Because biological control agents are screened in quarantine laboratories before their release, they are free of their natural enemies (particularly diseases and so-called hyperparasitoids) so their impact can be greater than at their place of origin. Success is also affected by interactions between biological control agents and crop varieties, as seen with an effective green mite predator that finds refuge in the hairy tips of some cassava varieties.

Adapting to Africa

Unfortunately, farmers and politicians alike easily forget the impact of biological control once arthropod and weed populations have reached acceptable levels. In addition,

Table 1. Economic impact analysis of ongoing biological control projects in Africa: the estimated savings were achieved for costs far below 1%.

Pest species and year of first occurrence	Typical losses in yield	Biological control agent	Start of campaign	Area under economic analysis	Reduction in loss	Estimated savings in US$ million
Cassava mealybug 1973 (ref. 7)	40%	Encyrtid wasp *Anagyrus lopezi*	1981	27 African nations	90–95%	7,971–20,226
Cassava green mite 1971 ‖	35%	Phytoseiid mite *Typhlodromalus aripo*	1983	Nigeria, Ghana, Benin	80–95%	2,157
Mango mealybug 1980s (ref. 8)	90%	Encyrtid wasp *Gyranusoidea tebygi*	1987	Benin	90%	531
Water hyacinth 1980 (ref. 9)	66% *	Weevil *Neochetina eichhorniae*	1991	Benin	36% †	260
Red waterfern 1978 (ref. 10)	‡	Weevil *Stenopelmus rufinasus*	1997	Republic of South Africa	§	206

* Damages of US$84 million to fishing and trade at peak of infestation. † By 1999, full impact not yet achieved. ‡ Average damages of US$533 per respondent (30 in total). § After three years the weed was not considered a problem anymore. ‖ O. Coulibaly and R. Hannah, personal communication.

achieving pest control — finding equilibrium levels — often takes many years and the result is not the instant 'extermination' that is wished for by many farmers. But although not all pests are amenable to classical biological control, many more species should be targeted. Certain pan-tropical pests — which had invaded the tropics long before entomologists first described them — require worldwide exploration to find their native country and potential natural enemies. Cereal-stem borers are good examples of pests against which regional exchange of parasitoids has proved particularly promising[5].

Although the mass release of beneficial insects is sometimes profitable in Europe and North America, this approach has generally failed in tropical Africa because of the high cost of insect-rearing facilities. This situation is unlikely to change in the near future. The mass release of insect pathogens, such as Green Muscle, shows more promise because of the greater ease of production and storage of the fungal spores. Finding an effective pathogen is one thing, but there are many additional challenges, such as creating production capacity, identifying key markets, solving conflicts over intellectual-property rights, and harmonizing regulatory and quality-control procedures. None of these were easy with Green Muscle.

Although the Food and Agriculture Organization of the United Nations ranked Green Muscle top in both environmental compatibility and lack of negative impact on human health, it still has not been widely used in Africa beyond the countries participating in its development, mostly Niger and Mali, where it has been deployed against Sahelian grasshopper outbreaks since 2000. On a smaller scale, it was used in field trials against grasshoppers in Benin, Cabo Verde and some east African countries. There have been fewer field trials against locusts. The absence of a uniform regulatory framework in a fragmented market is largely to blame for the limited sales. Existing regulations concern synthetic pesticides and are slowly being adapted to biopesticides. It also does not help that so many countries are involved, each with its own authority in such matters, and that the continental agency for coordinating plant protection legislation and interventions, the Inter-African Phytosanitary Council, has only an advisory capacity and needs more support.

Proof that technical problems do not limit the use of Green Muscle is shown by the successful continent-wide application of an Australian version of Green muscle, Green Guard. The environmental benefits of Green Muscle, including the protection of birds migrating through the Sahara, should appeal to donors who previously provided other insecticides for free. Therefore, the question is whether concerned European and African governments and international donors can muster the political will to implement this new solution, which they asked for back in 1989.

Natural advantages

The same argument could apply to other environmentally friendly entomopathogens (insect viruses, bacteria or fungi). Although agents that target a narrow spectrum of species with satisfactory killing power are common, this is not sufficient for their successful deployment in the field. As seen with Green Muscle, the creation of production capacity and other problems need to be solved. Farmers interested in growing vegetables for export find the use of entomopathogens particularly attractive, as European Union regulations impose near zero-tolerance limits on pesticide residues.

Another promising approach to biologically oriented pest control involves insecticidal plant extracts, known as botanicals, which are easily available. Local African knowledge by botanists and elders is disappearing and often does not reach the farmer. Although some of these plant products are as poisonous as synthetic insecticides and would need regulatory testing, others, such as neem seed or leaf extracts, have demonstrated no negative side-effects[6]. But use of these extracts is still not widespread — despite the abundance of their source plants — because their commercial production by small-scale entrepreneurs has not yet taken off, as it has in India[6].

These three options, classical biological control agents, entomopathogens and plant extracts (if screened correctly), share several advantages: they are fully compatible with new crop varieties and cultural practices, and they preserve indigenous natural enemies. Unlike the extensive monocultures of the developed world, the small African fields, rich in other plants ('weeds') and often surrounded by strips of native vegetation, provide a welcoming environment to biological control agents.

In Africa, increases in production for the past 40 years have barely kept pace with population growth. They were mostly obtained by increasing cultivated areas through expansion into marginal, often biodiversity-rich and sometimes protected areas. As fallow periods are being phased out across Africa, with negative effects on soil regeneration and biodiversity, production on existing cultivated land must be intensified by using high-yielding varieties, a careful mix of organic and inorganic fertilizer, improved pesticides, and by maintaining natural enemies. Without help for subsistence farmers to buy fertilizers, it is likely that they will be pushed further into marginal or protected areas.

The eco-friendly options discussed here offer sustainable yield increases and allow us to get away from unsustainable insecticide use. Implementation of such programmes requires better education of stakeholders, best achieved by the many types of IPM farmers' field schools. In addition, international collaboration, public investment under fair-trade practices, political will and public support need to improve. With a clear vision, a pragmatic approach and good leadership, many countries could adopt this approach today. ■

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