Can the biofuel crop, *Jatropha curcas*, be used as a locally-grown botanical pesticide? A lab and field study in Zambia

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Abstract

Jatropha curcas is grown as a biofuel crop in the tropics, and in many parts of Africa it also has a number of domestic uses, e.g. it is frequently grown as a hedge. The collapse of the biofuels market in Zambia has inspired a search for alternative uses for this plant. Previous laboratory studies suggested that Jatropha exhibits a range of beneficial properties, including pesticidal properties. In this paper, we report a series of studies aimed at testing whether formulations of Jatropha powder or oil are effective against storage pests infesting cowpeas and maize. These include laboratory experiments in the UK and field studies conducted with village farmers in Zambia. We report these findings, and discuss the role of participatory research in aiding the adoption of locally-grown botanical pesticides amongst resource-poor farmers in rural Zambia.

Introduction

Jatropha curcas is a pan-tropical, non-edible shrub within the family Euphorbiaceae (Carels, 2009) that is commonly grown as a hedge plant in many regions of Africa. There have been several studies reporting anti-arthropod activities of *Jatropha curcas* plant parts, most likely due to the toxic protein curcin and/or phorbol esters (Devappa *et al*., 2010). Recently, there has been an increase in the cultivation of Jatropha in some parts of Africa, due to its potential value as a biofuel crop. However, in Zambia, the Jatropha biofuel market has collapsed and many farmers are left with a worthless crop that is either left unattended or is replanted. As a consequence, alternative uses for the plant are sought.

Recent literature suggests that Jatropha oil, seed or leaf extracts have a range of pesticidal and antimicrobial properties. For example, Jatropha oil acts as a repellent against termites (Acda 2009); Jatropha seed extracts kill the larvae of mosquito species that vector infectious diseases such as malaria (Sakthivadivel and Daniel 2008); Jatropha leaf extracts significantly reduce fungal pathogen growth (brown blotch disease, *Colletotrichum* spp.) in both cowpea (Onuh *et al*., 2008) and banana (Thangavelu *et al*., 2004); and the sap of Jatropha inhibits the growth of several common bacteria (*Staphylococcus*, *Bacillus* and *Micrococcus* spp.), and nematode parasite species (*Ascaris lumbricoides* and *Necator americanus*) (Fagbenro-Beyioku *et al*., 1998). Moreover, extracts from Jatropha leaves exhibit insecticidal activity against a range of Lepidopteran species (Ratnadass *et al*., 1997; Valencia *et al*., 2006; Phowichit *et al*., 2008), and Jatropha seed extracts are reported to cause 97 - 100% mortality against stored product pests, such as *Sitophilus* weevils (Asmanizar *et al*., 2008) and *Callosobruchus* seed beetles (Adebowale and Adedire, 2006). However, most of these previous studies were laboratory-based studies using a range of extraction methods that are not readily available to resource-poor farmers and so the relevance of these findings to field conditions is unclear.

As part of a much larger study exploring the nature of knowledge exchange between farmers and scientists called *Bridging Knowledge Systems for Pro-Poor Management of Ecosystem Services*, the aim of the current project is to determine whether more readily available Jatropha products (seed oil and powdered leaf) is effective against stored product pests affecting stored maize and cowpeas. Inevitably, when determining the efficacy of a new pesticide, there is an inherent trade-off between the realism typified by farmer-led field evaluations ('farmer experiments') and the degree of control over extraneous influences typified by well-designed and replicated laboratory-based studies ('lab experiments')/ ! half-way house along this trade-off curve is to design well-controlled experiments that are conducted in collaboration with farmers in the field ('field experiments')/ This paper describes preliminary results using each of the approaches.

Methodology

(a) *Farmer experiments*: These experiments were designed by a consortium of individuals from Lancaster University, UK, the Green Living Movement (GLM), a Zambian based NGO that with local farmers to experiment and test alternative agricultural practices and innovations, and a farmer from Chibobo in Central Zambia – "Professor" Spider !llan/ These experiments are conducted on an ad hoc basis using a limited supply of Jatropha oil, leaf powder and seed cake, and were part of a wider study exploring the uses of locally-available plants as botanical pesticides (see Vermeylen and Wilson, this volume, for more details.

(b) *Lab experiments*: These studies were conducted at Lancaster University in the UK as part of an MSc project. They main experiments used Jatropha oil (diluted with sunflower oil to make concentrations of 0%, 0.1%, 1%, 10%, 50% and 100% Jatropha) on cowpeas to determine their effects on egg-laying behaviour and larval survival of *Callosobruchus maculatus* beetles, compared to non-treated controls. The experiments involved 'no choice' and 'choice' assays in which mated females were given access to cowpeas lightly coated in the oil formulation for 7 days and the number of eggs laid after 24 hours and 7 days was determined and their survival to adult emergence recorded.

(c) *Field experiments:* This experiment involved a collaboration between the Kasisi Agricultural Training College (KATC) in Lusaka, Lancaster University, UK, and ten farmers living near KATC. The aim of these studies was to test efficacy of Jatropha leaf powder, both as a dry formulation and diluted in cold water, against the storage pests of maize, mainly *Sitophilus* beetles. The experimental design was aimed at maximising statistical power within the constraints imposed by large numbers of treatments and replicates. There were 5 treatments: a dry control (maize seeds); a wet control (maize seeds that had been soaked in cold water for 2 minutes before being dried to 0% humidity as determined by a grain moisture probe); a synthetic chemical pesticide treatment (*Sumba Super Dust*, used at the manufacturers recommended rate); a Jatropha powder treatment (dried leaves crushed to a fine powder with a mortar and pestle and applied at a rate of 2% w/w); and a Jatropha solution treatment (dried leaf powder soaked in cold water overnight to make up a 10% solution w/v and maize seeds dipped in the solution for 2 mins before being dried in the shade to 0% humidity and re-bagged). The 5 treatments were replicated 4 times with each of the farmers using 20kg bags of maize. Bags of the same treatment were stacked together to maximise treatment effects and the normal storage mechanism, but different treatments were kept apart within a single store room. Immediately after treatment, and at monthly intervals thereafter for 6 months, 4 separate samples (each weighing approximately 250g was taken from each bag and the following metrics determined: (i) number of insects per weighed sample and their identity; number of holes per seed for each of 250 seeds, replicated 4 times; and (iii) weight of 1000 seeds.

Results

(a) *Farmer experiments*: There was anecdotal evidence for an effect of Jatropha seed cake on the incidence of attacks on stored maize by rodents, but as there was no adequate control, it was difficult to establish its robustness. Jatropha leaf powder was not effective. Jatropha oil was also reported by the village "professor" to be effective against stalk borer/

(b) *Lab experiments*: In the no-choice assay, there was no effect of the different oil treatments on the number of eggs laid after 24 h. However, after 7 days, there were significantly fewer eggs laid on the cowpeas that received the 50% and 100% Jatropha oil treatments, compared to those treated with oil comprising 10% Jatropha or less. There was a significant impact of oil treatment on the number of adult beetles to emerge: untreated cowpeas = 27.6 + 7.5; 0% Jatropha oil (i.e. 100% sunflower oil) = 0.8 + 0.2; 0.1% Jatropha oil = 0.4 + 0.1; 1% - 100% Jatropha oil = zero emergence. In choice tests, after 24 hours there was significant avoidance of all the oil-treated seeds, with 47% more eggs being laid on the untreated seeds than the treated ones. However, amongst the oil-treated seeds, the oil treatment (% Jatropha) did not significant influence the number of eggs laid per seed. Results after 7 days were broadly similar.

(c) *Field experiments:* Preliminary analysis, conducted on sampling data from 3 months after the experiment started revealed the following patterns (Table 1) : (i) As expected, according to most metrics, the synthetic chemical (Sumba Super Dust) reduced the incidence and impact of stored product pests. (ii) The number of insects (mainly *Sitophilus* beetles) infesting the maize did not differ between the control group and the group treated with Jatropha powder, but in the maize treated with Jatropha solution, the number of insects was approximately 3 times greater than in the dry untreated maize and 25% greater than in the wet control maize (i.e. maize that had been pre-treated by soaking in cold water for 2 minutes); wetting the maize like this results in a doubling of the number of insects compared to the dry controls. (iii) The number of maize seeds attacked and the total number of holes made by exiting insects was not affected by treating with Jatropha powder, but both were significantly increased in seeds that had been soaked in Jatropha solution. Soaking in water enhanced the number of seeds attacked but not the number of exit holes recorded. (iv) The mass of seeds was significantly reduced in both water treatments (control and Jatropha solution), but adding Jatropha to the solution did not affect the weight loss.

Conclusion

There are pros and cons to different methods for testing the efficacy of botanical pesticides. Field experiments provide a suitable compromise between well-controlled lab experiments with limited realism to the field setting and farmer-led observations that are not well controlled, randomized or replicated. The studies reported here highlight these constraints. The field experiments suggest that Jatropha leaf powder has limited utility as a botanical pesticide against storage pests. Likewise, Jatropha leaf solution fails to protect stored maize. Indeed, soaking maize in water for just two minutes and then drying significantly enhances susceptibility to *Sitophilus* weevils, and adding Jatropha leaf powder to the solution appears to enhance its attractiveness to insects and the damage they inflict. Further lab studies will be required to determine the cause of this, but it is possible that this could be exploited in a form of "push-pull" approach, with the Jatropha solution pulling insects away the main storage crop, which could be protected by a different botanical pesticide or repellent.

Table 1: Effects of Jatropha curcas leaf powder and solution on infestation of maize seeds with stored product pests

Treatment: **Metric:**	**Control (dry)**	**Jatropha powder**	**Control (wet)**	**Jatropha solution**	**Sumba chemical**	**F** (df = 4,195)	**P**
Number of insects per kg seeds (mean ± SE)	29.50 ± 3.55a	38.40 ± 3.26a	71.25 ± 6.60b	100.87 ± 8.55c	4.47 ±0.45d	145.92	<0.0001
Number of seeds attacked per 1000 (mean ± SE)	48.70 ± 4.08a	47.50 ± 2.91a	65.20 ± 5.81b	124.70 ± 9.48b	26.40 ± 2.04c	45.33	<0.0001
Number of exit holes per 1000 seeds (mean ± SE)	92.60 ± 9.36a	93.30 ± 6.09a	96.40± 7.81a	223.60± 17.12b	43.90±3.38 c	46.00	<0.0001
Mass of 1000 seeds (g) (mean ± SE)	363.60 ± 2.08a	365.10 ± 1.61a	353.40 ±1.68b	357.00 ± 2.33b	362.40 ± 2.00a	6.30	<0.0001

Means that are not significantly different from each other share a common letter, as determined by Bonferonni tests. F and P values are more an ANOVA model.

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