

# Hawaiian Papaya: GMO Contaminated



photo by Jeri Di Pietro

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**Hawaii SEED<sup>1</sup>**

**2006**

[www.gmofreehawaii.org](http://www.gmofreehawaii.org)

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<sup>1</sup> GMO Free Hawaii changed its name to Hawaii SEED in February 2006 .

## EXECUTIVE SUMMARY

In 1998, the first GMO<sup>2</sup> Papaya was commercially released into Hawaii's growing environment. Dr. Dennis Gonsalves and Dr. Richard Manshardt created this papaya ringspot virus (PRSV) resistant GMO fruit and were experimenting with its release in PRSV ridden Puna, the main papaya growing area of Hawaii. While the GMO Papaya is resistant to papaya ringspot virus, it brought many more problems than it solved. The GMO Papaya has closed lucrative export and organic markets and always has a low price point. This technology has come with too many strings attached and Hawaii has lost almost half of its papaya farmers.

Another unintended problem is GMO contamination. In 2003, GMO Free Hawaii became very concerned with the gene flow of the GMO Papaya. First, we used the GUS gene test to see how much contamination was on our farms and in our community. After consistently finding 30-50% of the seeds and leaves we tested having some kind of air or seed contamination, we wanted to know more. We put out calls for independent, peer-reviewed academic studies to examine the levels of this GMO Papaya contamination, to no avail. In 2004, GMO Free Hawaii designed a study to look at the extent of GMO contamination around the state.

The methodology of this Pilot Survey included three composite samples of approximately 10,000 seeds from around the islands (Hawaii, Oahu, Kauai) being collected from non-GMO growing locations such as organic and conventional farms, backyard gardens and feral roadsides. Two composite samples each of seeds and leaves from organic farms were collected on Hawaii and Kauai. Three samples of University of Hawaii non-GMO seed varieties were purchased directly. Seeds and leaves were sent to an independent laboratory, Genetic ID, for PCR (Polymerase Chain Reaction) industry standard testing.

The results indicate massive GMO contamination of papaya seeds on Hawaii Island, of the order of 50%, substantial GMO contamination on Oahu (<5%) and thankfully, only traces of contamination on Kauai (0.0%). Both organic farms tested had no GMO trees unintentionally planted, but sadly, were discovered to have air contamination of the seeds in their fruits (<5% on Hawaii Island and 0.01% on Kauai). Most shocking was the GMO contamination of the University of Hawaii's non-GMO papaya seed supply (Waimanolo Solo variety) at greater than 0.01% but less than 0.1%.

**In 2006, we repeated this last test and found the Waimanalo Solo to still be GMO contaminated at the same percentage.** As the University of Hawaii claims not to be growing this seed near GMO Papaya trees, they must have

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<sup>2</sup> In this report GMO means genetically modified organism and is synonymous with GE or GM or genetically engineered.

untested GMO trees in their non-GMO orchards or not be bagging the flowers properly to keep out unwanted GMO pollen.

The two main routes of GMO contamination appear to be air and seed contamination. Air contamination refers to GMO contamination of the seeds by GMO pollen flow traveling by wind, insect, animal or human. Flesh of the fruit may be non-GMO while any number of seeds inside may be GMO. Seed contamination refers to unintended GMO contamination of the traditional seed supply leading to unintended GMO trees, which have GMO leaves, fruit flesh, and at least three quarters GMO seeds. Most concerning has been the loss of lucrative export and organic markets caused by the GMO Papaya contamination leading to expensive testing and roguing to non-GMO Papaya growers.

The University of Hawaii and Pacific Research Basin have responded inadequately to the news of our test results. Their insufficient attempts at follow-up studies have included testing too few UH seeds to provide statistically significant results, a pollen study by an undergraduate on the island with the least contamination and a promise of a study by Carol Gonsalves (Dr. Gonsalves' wife) that has not materialized. Promises of GUS testing for papayas being available to farmers and gardeners through the Cooperative Extension service have not materialized either. Finally, no attempts at GMO Papaya clean-up by the responsible institutions have been made, to date.

Finally, this pilot study shows more GMO Papaya contamination than anyone expected. Our recommendations include:

- 1. Governments around the globe should not introduce the GMO Papaya into any new growing regions. Even as a field trial, GMO Papaya cannot be contained.**
- 2. Considering the adverse consequences of the GMO Papaya, the Hawaii Department of Agriculture should not commercially release any more GMO crops in Hawaii.**
- 3. The University of Hawaii should clean up the GMO contamination in their non-GMO papaya seeds before selling any more.**
- 4. GMO Papaya testing should be offered to Hawaii Island farmers and gardeners either free of charge or at a nominal cost by the University of Hawaii and PBARC/USDA (Pacific Basin Agriculture Research Center/United States Department of Agriculture), so they can rogue out GMO Papaya contamination.**
- 5. Education about using traditional and alternative methods of Papaya ringspot virus management including introducing PRSV tolerant**

**varieties should be actively offered to farmers by the University of Hawaii and PBARC/USDA .**

- 6. An independent peer-reviewed study examining the full extent of the GMO Papaya contamination in Hawaii should be authorized by the Hawaii Department of Agriculture.**
- 7. An independent peer- reviewed study examining the possible health effects on humans of the GMO Papaya consumption should be authorized by the Hawaii Department of Agriculture.**

## INTRODUCTION

The complete lack of forethought and recklessness with which the University of Hawaii released the Genetically Engineered Papaya into our pristine Hawaiian growing environment will be leaving us with devastating repercussions for generations to come. Walter Ritte, Native Hawaiian Activist, has called this part of the Mana Mahele, the division of the spirit of the land. They were enamored with a new technology and threw precaution to the wind when they released this self-replicating experiment into the wilds of nature and human caprice. The narrow confines of thought and regulation in the lab do not exist out here where we farmers grow. Our economics have a narrow margin and we are wisely conservative unlike our public institutions. We operate mostly at the mercy of Mother Nature and sometimes in partnership with her. Plants grow our products; we nurture the plants hopefully.

The narrow slice of the story portrayed by the University of Hawaii and Dr. Dennis Gonsalves' collaborators in promoting this untried, sketchy, new technology makes it sound like an unmitigated success. If they considered the implications of the GMO contamination they would wreak on Hawaii, they have even more to answer for than they already do. The loss of markets, contamination, and poor performance of this GMO plant are a lesson in withholding further field-testing and commercial release of GMO Papayas abroad and any GMO crop in Hawaii. As farmers, we were curious about what this plant was really doing in our growing environment, so we went out and figured out how to find these lost rogue genes and count them.

One of the most frustrating aspects of this wave of GMO crops has been the misuse and abuse of science. This neutral tool, a way of knowing has been bought and used by both sides, such that we can no longer trust our institutions and their 'science'. We look to the funder to predict the result. Farmers, citizens, and communities have begun taking science back into their own hands and Civic Science is born. We use this impartial technique to learn truth about our circumstances. The truth was in the trees:

### ***Hawaii's Papayas are GMO Contaminated.***

## BACKGROUND

### **Papaya Ringspot Virus Epidemic**

The Papaya Ringspot Virus (PRSV) became an increasing problem for Hawaiian papaya farmers in the early 1990s. The Puna growing area on Hawaii Island was isolated and papaya ringspot virus remained endemic previously. Farmers slowed the PRSV spread by roguing out infected papaya trees. Eventually, the virus got out of control and found good conditions for its spread. Papaya farmers had been taught by the University of Hawaii to grow papayas in ways

that made them very susceptible to this disease. They planted in large, closely spaced, mono-cropped plantations of single varieties, with very little attention to improving the impoverished soil of lava rock. Alternative methods to decrease the threshold of the virus, such as inter-cropping, planting vector traps, silica sprays or increasing soil fertility for plant health were not offered by the extension service. The University of Hawaii did anticipate the coming virus problem and chose to develop a GMO solution to this problem instead of an IPM (Integrated Pest Management) plan or PRSV-tolerant variety. However, they introduced it into a precarious local agricultural system and into a global socio-economic system that didn't want it, creating a number of problems. According to the creators of the GMO Papaya, they developed the technology in the nick of time and offered it to the grateful and desperate farmers.<sup>1</sup> But, were the additional costs and problems worth it?

### **Genetically Engineered Papaya**

Dr. Dennis Gonsalves, then of Cornell University, and Dr. Richard Manshardt of University of Hawaii made a major scientific breakthrough when they were able to genetically engineer the papaya to be resistant to the papaya ringspot virus, a plant disease that can't be treated with chemicals.<sup>2</sup> The original transformation created SunUp, the pink flesh variety which was crossed with our traditional Kapoho Solo to get Rainbow, a hybrid, yellow flesh GMO variety. However, many scientists are trained to be narrow thinkers, experts in only a tiny area. Most seem unable to see the broad picture of agriculture in the field, the effects on ecology and the environment, and potential human health and social issues. This GMO Papaya may have been a success in the lab, but it was a disaster in the field.

Throughout the development of the GMO Papaya, the team showed little consideration for preventing GMO Contamination. Graduate student Maureen Fitch grew the plants from cells to plantlets in Hilo at the USDA Agricultural Research Service Facility in Hilo right near the main papaya growing area. The seed multiplication site in Kauai, managed by Dr. Richard Manshardt, was cited by the DOA for leaving male trees standing, which produced only pollen not seeds. He did not rogue them out until months after the citation, allowing months of 'pollen flow' to non-GMO papayas, one possible route of GMO contamination in Kauai.<sup>3</sup> The final outdoor field trial and multiplication site, Malama Ki, was in the middle of the papaya growing area. This allowed for not only pollen flow, but also theft.<sup>4</sup> The site was not guarded and fruit disappeared regularly. Previous to the introduction of the GMO Papaya, the culture of papaya production was to save the seed of tasty varieties by sharing with your friends and fellow farmers. There would be no reason to suspect that farmers and gardeners would suddenly stop exchanging and trading seed around, especially as it requires a lab test to tell the difference between GMO Papaya seed and real papaya seed.

### **Farmer Concerns**

The GMO Papaya has not been the savior promised by the University of Hawaii. While the GMO Papaya is resistant to papaya ringspot virus, the price for the GMO Papaya remains significantly lower. Papaya farmers interviewed in Puna in 2003 said they were getting 13-17 cents/pound for GMO Papayas. They earned 45-75 cents/pound for non-GMO papaya<sup>5</sup>. Their breakeven point was 35 cents/pound. The price of increased inputs reflects increased fertilizer requirements and the need for more fungicides as the GMO Papaya is more susceptible to blackspot fungus and phytophthora. Many farmers are losing money growing the GMO Papaya. The GMO Papayas are being dumped or fed to pigs. Some farmers are giving up growing papayas altogether. When asked about the low price of the GMO Papaya, developer Dr. Manshardt says he thinks the higher price for local varieties reflects the more lucrative Japanese market.<sup>6</sup>

The GMO Papayas were introduced despite overseas markets, which did not (and still don't) accept them. 40% of Hawaiian Papayas went to Japan previously.<sup>7</sup> Japan has closed their market to GMO Papayas these last eight years despite intense lobbying by the University of Hawaii and state politicians. This has been a major problem for papaya farmers. Even if the government eventually allowed GMO Papayas into Japan, consumers would continue to reject them. The Canadian market was lost for five years when GMO Papayas were introduced and has only recently reopened.<sup>8</sup> Therefore, GMO contamination of conventional papaya is important because it results in the loss of lucrative export markets.

Cornell University press releases take credit for the Papaya industry bouncing back after the peak of the papaya ringspot virus due to the introduction of the GMO Papaya on some farms.<sup>9</sup> This claim does not reflect the complexity of the situation. Plant diseases tend to come in waves and not all farmers planted GMO Papayas. The Hawaii County statistics reflect much lower numbers of acres, yields and sales than Cornell's press release.<sup>10</sup> There has been no independent peer-reviewed analysis of the wider economic effects of the introduction of GMO Papaya on Hawaii. The promoters of the GMO Papaya have chosen to only look at some of the effects. Carol Gonsalves (Dr. Gonsalves' wife) did a farmer interview study and published reports of high satisfaction with the GMO Papayas in *Agriculture Hawaii*<sup>11</sup>, but when Alan McNarie, an independent reporter, spoke with farmers in 2001 and 2003, he found 'Plenty Papaya Problems'.<sup>12</sup>

### **Papaya Freedom Fighters**

For Hawaii, as well as the rest of the world, GMOs are an agricultural 'solution' that comes with strings attached. Just before the commercialization of the GMO Papaya, the University of Hawaii placed an unguarded test site, Malama Ki, in the Puna growing area when farmers were experiencing big losses due to the Papaya ringspot virus. Seeds were stolen from the test site. One farmer was

sued, as the newly created understanding that seeds must be leased from biotechnology companies, not saved and shared by farmers had not yet reached the Big Island of Hawaii.

Another form of control over papaya farmers was in 2000 when a Japanese-owned papaya packer had the state legislature require Intensive Management Areas. The required plan aimed to create a Papaya ringspot virus-resistant GMO Papaya buffer zone around several larger farms that export non-GMO Papayas to Japan for a premium price. The University of Hawaii and the USDA aggressively influenced the small, primarily Filipino farmers in this buffer area to chop down their existing papaya plantations and plant this new GMO Papaya even though it meant they lost markets. Many farmers fed up with the loss of control over their production decisions, formed a group known as the Papaya Freedom Fighters to fight the intense pressure to chop down their trees. One of these farmers said, "These guys think they own the wind."<sup>13</sup>

Finally, diversified farmers, organic farmers, and backyard gardeners were not consulted about the introduction of GMO Papaya into their growing environment nor warned of the potential for GMO contamination. These GMO seeds come with invisible losses of freedom.

### **Exploring Contamination with GUS**

By 2002, the University of Hawaii had yet to follow up the release of the GMO Papaya with any environmental impact or seed supply contamination studies. At the time testing was not available to farmers. GMO Free Hawaii, a coalition of islands-wide grassroots groups concerned with genetic engineering of food and agriculture in Hawaii had begun to do some initial field -testing using a quick and simple test to see how far the contamination from the GMO Papayas had spread. In 2003, Dr. Manshardt taught GMO Free Hawaii how to effectively use this field test. When a specific reagent is placed on a seed or a leaf from a GMO contaminated tree, it reacts with an enzyme produced by a marker gene (the GUS gene) that was inserted into the papaya and turns bright blue. This test only applies to GMO Papaya in Hawaii and can be performed only because the GUS gene was used in the original genetic modification of papaya. GMO Free Hawaii began and continues to test papayas at community educational events and on farms to see if there was GMO contamination of the Hawaiian papaya.

What we found was heartbreaking. We expected to find contamination only on the island of Hawaii near the Puna growing area, as this is where most of the GMO Papaya is grown. However, we found some GMO contamination of papaya on Kauai, Oahu, Maui, Molokai, and Hawaii. GMO Contaminated Papayas were found growing feral on the roadside, in suburban backyards, on organic farms, and on conventional farms. We even found GMO contamination of papayas in the remote and sacred valleys of Waipio on Hawaii and Kalalau on Kauai.



## **Preliminary Study of GMO Contamination of Papaya**

After a couple of years of discovering 30-50% GMO contamination every time we did GUS testing, we wanted to verify the contamination levels more specifically (i.e. Are 1% of Hawaii's papayas contaminated or 10% or 50%?). We decided to design a pilot study that would sample the islands more systematically and send our tests off to an independent laboratory for PCR (Polymerase Chain Reaction) testing. While GUS testing is an effective, quick and relatively inexpensive method of determining the presence of GMO Papaya, laboratory testing using PCR can measure the amount of GMO DNA strands in a sample relative to non-engineered DNA strands. PCR is based on the DNA actually inserted into the plant during the genetic modification process and is the industry standard to analyze for GMOs.

We consulted several scientists to get the study design, sampling plan, testing, and test results interpretation correct.<sup>14</sup> The aim was to look at the traditional seed supply by making composite samples of seeds from many fruits from around an island or from one case study. This allows large numbers of seeds to be tested at once and, as each seed is an individual pollination event, gives an index of expected percentage GMO contamination for papaya in that area or island. Composite samples were collected from three islands (Hawaii, Kauai, Oahu), two individual organic farms (Hawaii and Kauai) as well as seed from three lines of non-GMO papaya purchased from the University of Hawaii. The samples were subjected to qualitative PCR testing at an independent PCR laboratory (Genetic ID) to determine the presence of GMO in the papaya seeds.

## **STUDY METHODOLOGY**

### **Pilot Survey Procedure Discussion**

This survey was a pilot study limited in scope, meant simply to see if contamination of Hawaii's papayas by the GMO Papaya has occurred and to determine whether further, more exhaustive sampling and testing is necessary.

Papaya fruits were collected into island composite samples from sites representative of all compass districts on Hawaii, Oahu and Kauai. Collection sites were tagged and location data recorded in order for our data to be replicable. Composite samples for three case studies were also collected. Two were of seeds from fruits and leaves from trees from an organic farm on Hawaii and one on Kauai. For the third case study packets of University of Hawaii non-GMO seed varieties were purchased directly.

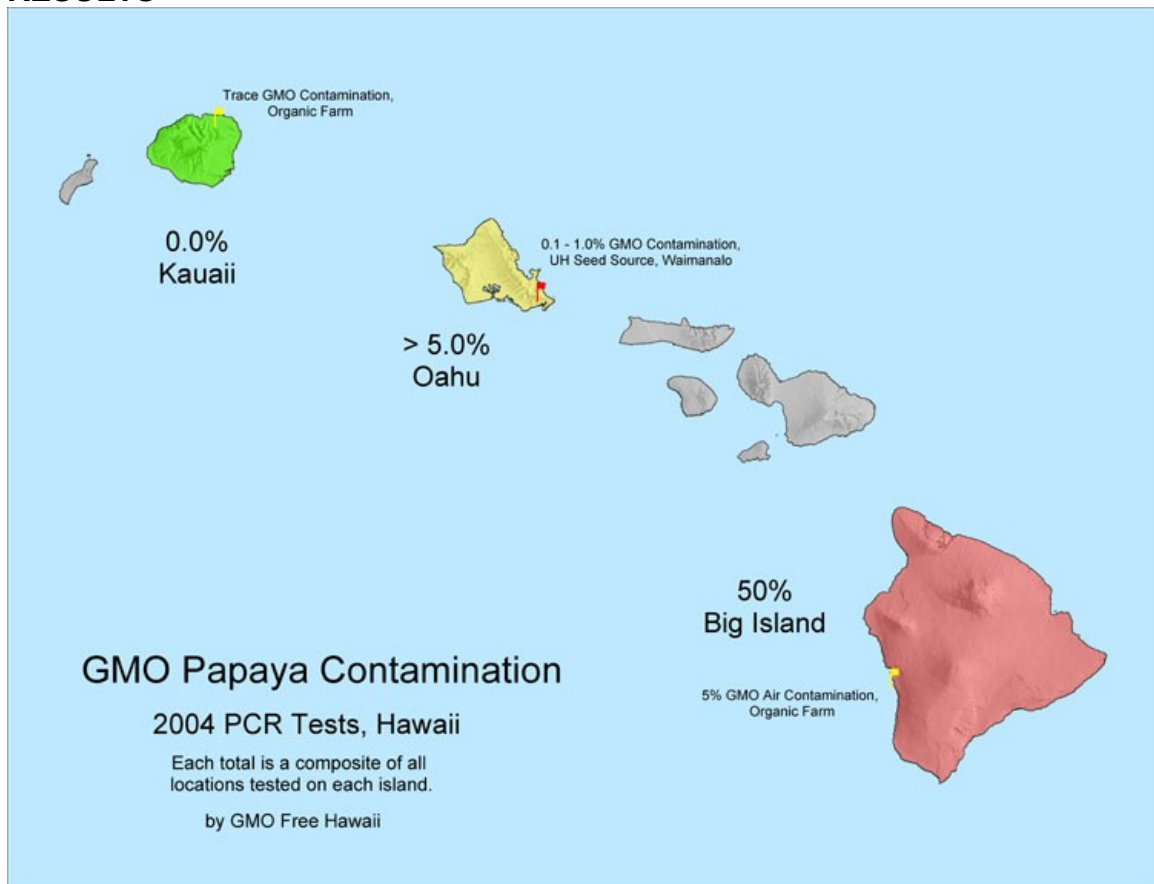
The composite seed samples were frozen upon collection and sent cold to Genetic ID, one of the world's leading laboratories in expert analysis of DNA. Genetic ID employed a sensitive technique capable of detecting specific sequences, known as PCR (Polymerase Chain Reaction). The DNA was analyzed for the presence of the cauliflower mosaic virus promoter, known as the

35S promoter, a sequence inserted into the GMO Papaya. If present, this gives proof of GMO contamination.

The reason for composite samples is to broadly determine the level of contamination of the traditional “seed supply”. Each papaya can contain a mixture of GMO and non-GMO seeds. Each papaya fruit may have 0-500 seeds in it. We aimed to have at least 10,000 seeds from each island from non-GMO locations (not intentional GMO Papaya farms) to get an accurate picture of the contamination. The PCR tests have a limit of detection of 0.01% GMO contamination. Thus, each seed counts in the results, but the results may not translate back to an exact number of contaminated fruits or trees.

The percentage of contamination is the best estimate of the apparent level of contamination as provided by Genetic ID, and usually falls between an upper and lower threshold or expressed as “greater than” or “less than” threshold percentages.

## RESULTS



**Figure 1. Map of Hawaii Islands showing GMO Contamination of Papaya (by Collin Bode)**

*Big Island Composite:*

Collected from mostly all organic (farms and yard) and very few feral. Composite collected from three areas, Kona (west), Hawi (north) and Puna (southeast) near the papaya industry. Seeds from three papaya fruits from three trees collected from five sites in each district = forty-five papayas were pooled. Seeds (previously collected and frozen) from an additional fifteen papaya fruits from Puna organic farms were added. Total = 15 + 45 = 60 papayas. The composites were actually in four bags, each separately tested, two sub-samples totaling 906 grams each appeared to be close to 100% GMO and two totaling 917.1 grams each below 5% GMO, for a total overall average of close to 50% contamination.

*Big Island South Kona individual organic farm composite test:*

One composite sample of leaves from 168 trees in one orchard tested no GMO, ruling out unintentionally planted GMO trees. However, a composite of seeds from twenty-seven papayas from these trees tested <5% GMO, indicating GMO contamination caused by pollen.

*Oahu Composite:*

One composite sample made up of seeds of thirty papaya fruits, twenty-eight organic fruits and two fruits from feral papaya trees. Seeds from fruit samples were collected from North and South each = three papayas from two sites, East and West = three from three sites. All seeds in one composite test: greater than 5% GMO contamination detected.

*Kauai Island Composite:*

One composite sample of seeds from seventy papaya fruits, approximately 200 to 300 seeds from each fruit. Twenty-two of were fresh papaya from an organic farm, backyard and feral populations. The rest (thirty-seven papaya fruits) were from previously collected and frozen, thirteen of which were conventionally farmed, the rest organic or feral. No GMO contamination was detected.

*Kauai: North side (Kilauea) individual organic farm composite test:*

One composite sample of thirteen leaves (one each from thirteen trees), showed traces of GMO at or near the detection limit of 0.01% (unquantifiable). One composite of seeds from twenty-eight papayas, traces of GMO at or near 0.01% (unquantifiable).

*University of Hawaii Seed:*

Packages of three varieties were purchased directly from UH, (grown at their Waimanalo, Oahu station), approximately 3,300 seeds in each.

**Solo Waimanalo variety: GMO contamination detected at less than 0.1% and greater than 0.01% (not quantified).**

Solo Sunset variety: no GMO contamination detected.

Solo Sunrise variety: no GMO contamination detected.

In summary, the results of our preliminary survey indicate massive GMO contamination of papaya seeds on the Big Island, of the order of 50%, substantial GMO contamination on Oahu (<5%) and thankfully, only traces of contamination on Kauai (0.0%). These results are summarized in Table 1.

Of the three case studies, the organic farm on Kauai had trace (0.01%) contamination. The organic farm on the Big Island of Hawaii (Kona) had no GMO trees but a surprising (<5%) air contamination of the seeds. Most shocking was the GMO contamination in the University of Hawaii seed supply- Solo Waimanolo variety- which are sold as non-GMO to growers from around the world. This result was found again in 2006

### **Solo Waimanalo tests positive again!**

**In 2006**, Hawaii SEED followed up on University of Hawaii's claim to have cleaned up their non-GMO papaya seed varieties. Three samples of 10,000 seeds of Solo Waimanalo, Solo Sunset, and Solo Sunrise purchased directly from the University of Hawaii were sent to Genetic ID. These seeds are sold with a note claiming that they are produced in fields not adjacent to GMO Papaya fields.

**The results show GMO contamination detected in Solo Waimanalo variety at greater than 0.01% and less than 0.1% again.** Solo Sunset and Solo Sunrise show no GMO contamination detected. A contamination rate of 0.01% indicates that there were between one and ten GMO seeds in the Solo Waimanalo 10,000 seed sample. These seeds will grow into one to ten trees putting out over 200 GMO seeds per week each during bearing years. Some of these seeds are sold to growers outside Hawaii where it is illegal to grow GMO Papaya. As the University of Hawaii claims not to be growing this seed near GMO Papaya trees, they must have untested GMO trees in their non-GMO orchards or not be bagging the flowers properly to keep out unwanted GMO pollen.

**Table 1. Results of 2004 GMO Papaya Contamination Pilot Survey**

**Island Composites**

<b>Island</b>	<b>Material tested</b>	<b>Route of Contamination*</b>	<b>% GMO Contamination</b>
Hawaii	seeds from 60 fruits	air & seed	50%**
	subsample 1		100%
	subsample 2		100%
	subsample 3		5%
	subsample 4		5%
Oahu	seeds from 30 fruits	air & seed	<5%
Kauai	seeds from 70 fruits		0%

**Case Studies**

<b>Organic Farm</b>	<b>Material tested</b>	<b>Route of Contamination</b>	<b>% GMO Contamination</b>
Hawaii (Kona)	seeds from 27 fruits	air	0.5%
	leaves from 168 trees		0%
Kauai (Kilauea)	seeds from 28 fruits	air	0.01%
	leaves from 13 trees		0%

**University of Hawaii Non-GMO Papaya Seeds**

<b>Seed Variety</b>	<b>Material tested</b>	<b>Route of Contamination</b>	<b>% GMO Contamination</b>
Solo Waimanalo	3,300 seeds	air and/or seed	0.01-0.1%
Solo Sunset	3,300 seeds		0%
Solo Sunrise	3,300 seeds		0%

**\*Route of Contamination:**

Air contamination refers to GMO contamination of the seeds by GMO pollen flow traveling by wind, insect, animal or human. Flesh of the fruit may be non-GMO while any number of seeds inside may be GMO.

Seed contamination refers to unintended GMO contamination of the traditional seed supply leading to unintended GMO trees, which have GMO leaves, fruit flesh, and at least 3/4 GMO seeds.

\*\*50% GMO Contamination result of Hawaii Island Composite Sample was reached when the lab tested the whole sample, which was frozen in 4 separate bags of approximately equal weight as separate composite samples. 2 bags showed 100% GMO contamination and 2 bags showed 5% contamination. The four were averaged for an approximate 50% GMO contamination result. Not every seed need be GMO to achieve a 100% PCR result as the test measures the number of GMO DNA strands in relation to the standard reference.

## **DISCUSSION**

### **Implications of GMO Contamination**

It is evident, even from this preliminary survey that contamination from GMO Papaya had spread substantially in the six years since its introduction in 1998 until this study in 2004. Although the routes of contamination were not examined in this study there are two main routes, air or seed. With air contamination, pollen travels through wind, insects, animals, humans and machinery. Seed contamination is largely through people buying, selling, trading, dropping, planting, but can be done by animals as well. The presence of GMO contamination in seeds from fruit, but not in the same trees on the organic farm in Kona of Hawaii Island, indicates that there is air contamination even in regions where there is no GMO Papaya industry.

Whereas promoters of GMO Papaya maintain that they can grow GMO Papaya in the neighboring field to non-GMO papaya without risk of contamination, the evidence we present shows that pollen flow is a major cause of GMO air contamination. In a textbook GMO Papaya plantation, only hermaphrodite trees are grown which primarily self-pollinate. In reality, no one rogues out all the male and female trees, and hermaphrodites do accept some pollen from other trees. GMO male and hermaphrodite trees continuously, and year round send pollen out into the environment, year after year as papaya is a perennial crop. Non-GMO female trees accept pollen from multiple sources, including any GMO trees nearby. Many diversified farmers, organic farmers, backyard gardeners, and wild ditches have all three genders growing. These people have no way of knowing which trees are GMO or non-GMO as it requires a lab test. Wind, insects, animals, people, and machinery can move the GMO pollen even further.

However, the main cause of GMO contamination in Hawaii is more likely to be people spreading seeds. Legally, GMO trees can only be grown by farmers who purchased the seed, watched the educational video, and signed a technology agreement. In reality, GMO Papayas were sold unlabeled in all our markets and everyone unknowingly takes them home and throws out (into the soil) GMO Papaya seeds. Our seedbed is filled with GMO Papaya seeds. The trees that grow out of these have an average of over one hundred GMO seeds in each fruit and produce several fruit per week, year round. The exponential spread of this contamination is easy to understand when the lack of labeling in the market is considered. Traditionally, people save seed and share seed, thus people pass GMO contaminated seed unknowingly all the time.

The situation with GMO contamination of papaya in Hawaii is different to a similar situation with hybrid corn on the US mainland. In hybrid corn, GMO contamination by cross-pollination, does not tend to accumulate because the corn from one year is harvested and new seed is planted the following year. However, papaya seed is routinely saved from edible fruit in Hawaii for cultivation, which means the GMO contamination will persist. In addition, papaya

seed is swapped, traded and exchanged by locals. This creates a gene pool, which can create further GMO contamination of papaya. These papayas have crossed back and forth for many generations, and what is in the genome of these GMO contaminated Papayas is unknown. Therefore, action is needed immediately to prevent the further spread of GMO contamination.

Most worrying is finding GMO seeds in samples comprised from the organic farms case studies, as this contamination can lead to loss of organic status. Organic markets don't allow GMOs, so organic farmers lose markets if their crops become contaminated. They can lose their certification for that crop or for their farm. The onus of testing to prove themselves GMO-free falls on organic farmers and is expensive. Organic farmers deal with all these concerns without receiving any benefit from this GMO Papaya that was released into their growing environment without their permission.

The Federal USDA Organic Standards, those of other countries and international organic standards, do not allow the inclusion genetic engineering at any point in the production chain. HOFA (Hawaiian Organic Farmers Association) now requires that farmers show proof of the certified non-GMO papaya seed they grew their trees from. Alternatively, organic farmers can test each tree to make sure they are not GMO. The University of Hawaii failed to educate their GMO Papaya growers to bag every flower, to protect the rest of the papaya growing community from this contamination. Dr. Richard Manshardt did a study on air contamination rates of organic papayas near GMO Papayas with cultivation recommendations,<sup>15</sup> but never made an effort to get the results out to organic farmers.

The market loss that many farmers have experienced with this GMO Papaya is deeply worrying and no compensation has been paid. The costs to the non-GMO, export oriented, and organic farmers who now have to test and rogue out GMO contaminated trees are disregarded. These costs are around \$700-800 per acre.<sup>16</sup>

Although, there are not many models on how to clean up GMO contamination globally, and the University of Hawaii has not begun the process, it must be done. Farmers and gardeners can rogue out papaya ringspot virus infected trees, reducing the need for this failed GMO Papaya experiment and use alternative virus management techniques. They can GUS test their papaya trees and rogue out the unwanted GMO trees. They can save clean, non-GMO seed by bagging a hermaphrodite flower just before opening and making sure only to grow trees from seed they saved.

### **Inadequate Response from University of Hawaii and PBARC**

After hearing about our test results, the University of Hawaii responded inadequately. They showed concern over the contamination of their non-GMO seeds, which they sell. However, they pursued confirming our results by having

Dr. Richard Manshardt's lab test only 200 of their seeds with the GUS gene test, which is appropriate for field use, but not as definite as PCR tests. This was a follow up of our 10,000 seed test by PCR. When they found no contaminated seeds in the first 200 seeds, they announced it was clean.<sup>17</sup> However, 200 seeds is not a large enough sample to detect the levels of GMO contamination that we found in the Waimanalo. This was a poor effort and inadequate follow-up for a seed source that is sold around the world, including in many countries where it is illegal to plant GMO seed.

Secondly, Dr. Manshardt's initial pilot study into pollen flow previous to commercial release in 1998 showed 38% contamination at up to 1/4 mile, which was much more extreme than expected. After hearing the results of GMO Free Hawaii's study in 2004, he followed the pollen concern up by having an undergraduate do some pollen flow work on Kauai, where the least contamination was found<sup>18</sup>.

The University of Hawaii agreed to start offering GUS testing for farmers and gardeners through their Cooperative Extension offices at reasonable cost, so unwanted GMO contamination could be detected. In 2006, this testing is still not available despite hundreds of requests for it. Most farmers and gardeners believe that it is the University of Hawaii's responsibility to provide free and accurate testing of all papaya trees as it was UH that released this contaminant into their environment without their permission.

One of GMO Free Hawaii's main demands for the University was to follow up the pilot study with a large-scale study looking further into the extent of the contamination. The next study should incorporate many more tests than our pilot could afford. The personnel chosen to design, implement, and publish in an academic journal should be academics who have no conflict of interest because they have financial or professional stake in the GMO Papaya. The demand was for an independent, peer-reviewed study. To date, the University of Hawaii has not done this follow-up study.

Dr. Dennis Gonsalves is currently the Director of PBARC (Pacific Basin Agriculture Research Center), a federally funded research center being built in Hilo. It will incorporate all the current USDA researchers in Hawaii. He planned to follow up our study by having his wife Carol Gonsalves repeat it. Then, he decided he'd rather look at pollen. To date, we haven't heard any results.

In Thailand when GMO contamination in papayas was discovered, the government immediately initiated a clean-up, The University of Hawaii and PBARC have yet to begin a clean-up. The University of Hawaii has many GMO crop projects and PBARC has plans to genetically engineer tropical crops that may be commercially released here (banana, pineapple, lime, lychee). Similar GMO contamination scenarios are possible. We have to expect that each crop they release will force the rest of the industry to grow GMO contaminated



versions of this crop without their permission. The genetic inserts are not necessarily stable in multiple unplanned generations and may have additional unexpected consequences.<sup>19</sup> Under current US law, farmers are wide open to lawsuits from patent-holders of these genes, regardless of how they end up on their farms.<sup>20</sup>

Experimental or other GMO Papaya releases are either planned or already underway in Brazil, Australia, Mexico, Thailand, Malaysia, Philippines, Vietnam, Hong Kong, Taiwan, Jamaica, Venezuela, Colombia, Ecuador, Tanzania, Kenya and Uganda. Farmers and governments need to know about all the GMO contamination and the resulting market losses that happened in Hawaii in just six years. Based upon our experience with the GMO Papaya, each agricultural industry in Hawaii that allows a release of a GMO crop will face similar problems.

## **RECOMMENDATIONS**

- 1. Governments around the globe should not introduce the GMO Papaya into any new growing regions. Even as a field trial, GMO Papaya cannot be contained.**
- 2. Considering the adverse consequences of the GMO Papaya, the Hawaii Department of Agriculture should not commercially release any more GMO crops in Hawaii.**
- 3. The University of Hawaii should clean up the GMO contamination in their non-GMO papaya seeds before selling any more.**
- 4. GMO Papaya testing should be offered to Hawaii Island farmers and gardeners either free of charge or at a nominal cost by the University of Hawaii and PBARC/USDA, so they can rogue out GMO Papaya contamination.**
- 5. Education about using traditional and alternative methods of Papaya ringspot virus management including introducing PRSV tolerant varieties should be actively offered to farmers by the University of Hawaii and PBARC/USDA .**
- 6. An independent peer-reviewed study examining the full extent of the GMO Papaya contamination in Hawaii should be authorized by the Hawaii Department of Agriculture.**
- 7. An independent peer-reviewed study examining the possible health effects on humans of the GMO Papaya consumption should be authorized by the Hawaii Department of Agriculture.**

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