Space shuttle exhaust has minimal effect on fruit, bees

MERRITT ISLAND, Fla. — Agricultural Research Service scientists have been cast in an important new supporting role in a favorite American drama—space shuttle launches from John F. Kennedy Space Center.

The somewhat unusual role, far from "show business", has taken 3 years of painstaking research.

At the request of the National Aeronautics and Space Administration, ARS scientists, working with scientists at North Carolina State University, investigated the effects of exhaust clouds generated by shuttle launches at Merritt Island, Fla. They evaluated the Shuttle's possible influence on native plants and insects, on a commercially important beekeeping industry, and on large citrus groves in the area. Citrus is a major crop on Merritt Island, worth $7.2 million annually

The area around the shuttle launch site is part of the Merritt Island National Wildlife Refuge. "The island is a mosaic of different coastal ecological communities," says ARS plant physiologist Walter W. Heck, who led the cooperative research which resulted in the first of two reports to NASA

Because preliminary investigations showed that hydrogen chloride gas is the major plant toxin in solid rocket fuel, Heck's team began by showing that aluminum oxide or alumina and hydrogen chloride gas were the most likely components of exhaust from solid rocket fuel to harm biological systems.

Greenhouse exposure chambers were continuous-stirred-tank reactors, which assure that conditions inside are uniform. They were built and tested for use with hydrogen chloride gas. One chamber had a dispensing system for aluminum oxide or alumina particles.

Also, a controlled burn facility was designed and tested by North Carolina State University engineering graduate student Allen H. Sawyer. The facility exposed plants to solid rocket fuel exhaust in tall field chambers The field chambers were modified from the standard open-topped chambers that are often used in air pollution studies. With the modifications, they had a top but no stirrer; other changes assured that conditions were nearly uniform inside.

Twenty-four plant species native to Florida were grown in the greenhouse. They were screened for sensitivity to hydrogen chloride, aluminum oxide, hydrogen chloride, and solid rocket fuel exhaust.

Exposures of selected plants to large doses of aluminum oxide (50 milligrams per cubic meter during a 60-minute period) did not cause injury or affect growth. Plants responded to mixtures of aluminum oxide and hydrogen chloride in the same way they did to hydrogen chloride alone—the threshhold concentration for injury was 3 to 4 parts per million (ppm) for an 80-minute exposure.

Solid rocket fuel exhaust mixtures were monitored by determining the hydrogen chloride concentrations in the field chambers while solid rocket fuel was being burned. Results from exposing plants to the exhaust mixtures corresponded to results from comparable greenhouse exposures to hydrogen chloride.

"Although insects are an important part of all ecosystems," says Heck, "they have been largely overlooked in air pollution studies."

For the NASA investigations of solid rocket fuel exhaust, representative insect species were chosen: a pollinator the honey bee; a predator, the common lacewing which preys on a number of citrus pets; and the ubiquitous corn earworm, which damages many field and garden crops. All are found on Merritt Island.

An effective lethal dose, ED50, is defined as a dose that causes 50 percent of the insects to cease movement. It generally means death but does not prove it.

The ED50 of hydrogen chloride for forager honey bees was 100 ppm for 120 minutes, and 150 ppm for 30 minutes. The ED50 for lacewing larvae was 150 ppm for 60 minutes, and that for the most sensitive life stage of the corn earworm, 102 ppm for 60 minutes.

Brood production of active bee colonies was only temporarily affected by multiple exposures to solid rocket fuel exhaust at hydrogen chloride concentrations of 10 ppm. Multiple exposures of bee colonies to 20 or 30 ppm, however, caused a loss of brood production. When exposures ended, brood production started to increase, but 2 of the 4 colonies ultimately were lost.

The results of these studies suggest that no direct observable acute effects on insects will be found as a result of the space shuttle program. The harmful doses are higher or more prolonged than those the shuttle actually causes. However, exposed honey bee colonies could suffer stress-related diseases, says Heck.

In a second report, researchers headed by plant pathologist Allen S. Heagle determined the response of citrus to simulated "rain" acidified with solid rocket fuel exhaust or with hydrochloric acid.

"There are no reports on the effects of acid rain on plants where the acidity is caused principally by hydrogen chloride," said Heagle. Therefore, researchers sprayed hydrochloric acid solution on mature Valencia orange trees in a commercial grove at Merritt Island and on potted trees at Raleigh. Trees sprayed with pond water were used as controls.

In measuring acid levels, a pH of 7 is neutral. Acid at pH 2 0 caused visible symptoms on flowers, leaves, petioles, stems, and immature fruit; injury was moderate at 1.0 and severe at 0.5.

Calamondin plants are an ornamental citrus that produce small fruit year round and are commonly used in greenhouse research. Potted calamondin plants were exposed to hydrogen chloride solutions at pH 1.1 or 0.7 applied as "rain" during flowering or after fruit set. Deionized water was the control.

Calamondin reacted to hydrogen chloride solutions in much the same way that mature Valencia oranges did. Potted Valencia oranges at Raleigh reacted similarly to the grove oranges in Florida.

In order to treat several plant species, the solid rocket fuel exhaust system was redesigned by North Carolina State University engineering graduate student Randy Perry to force solid rocket fuel emission through a "rain" tower. To acidify the simulated rainfall to various degrees, different amounts of fuel were burned and the emissions collected. The simulated rainfall then passed through the emissions. Marsh elder, radish, and soybeans were more sensitive than calamondin plants.

The results suggest that near launch areas where solid rocket fuel is used, plants will be injured if hydrogen chloride rain occurs having acid levels below pH 2.0.

"We expect that direct damage to citrus will be minor, unless the same area is repeatedly affected," Heagle says. In fact, mature Valencia orange trees that were severely injured by hydrogen chloride solutions at pH 0.5 in 1978 yielded as much as in 1980 as did the controls.

The 3-year research study was supported through an Interagency Agreement with NASA, and cooperatively done by ARS and North Carolina State University.

NASA was represented by plant physiologist William M. Knott, in charge of the Environmental Monitoring Program for the Kennedy Space Center. Knott's coded mailing address is MD-RSB-3, John F. Kennedy Space Center, FL 32899

Exhaust clouds blanket the surrounding areas as Space Shuttle Columbia lifts off from the launch pad at Merritt Island, Fla. (Photo courtesy of NASA)

The Mississippi River sends 10 tons of soil per second or about 300 million tons of sediment per year into the Gulf of Mexico. Soil erosion and sedimentation combine to make up the number one land use problem in the 10 Great Plains states.