Yellow Rain and the Cloud of Chemical War

The State Department says that Russia is promoting new forms of chemical warfare in Southeast Asia, but others are cautious

Three new samples of yellow rain, the substance said to be being sprayed on populations in Laos and Kampuchea, have been found to contain high levels of certain fungus-made toxins known as trichothecenes.

These findings, if they mean what the State Department says they mean, have deeply troubling implications for future restraint over chemical and biological weapons, and for arms control in general. They would indicate a violation of both the 1925 Geneva Protocol outlawing chemical weapons, and the 1972 Biological Weapons Convention, which includes toxins. "These agreements, signed by both the Soviet Union and Vietnam, . . . are being flagrantly violated," says Richard Burt, assistant secretary of state for politico-military affairs.

These charges are made in the context of allegations of chemical warfare which have been made by refugees from Laos and Kampuchea since 1976. For years the U.S. government was unable to verify these claims.

The picture seemed to change dramatically on 13 September this year. On a visit to Berlin, in the wake of a vigorous antinuclear demonstration, Secretary of State Alexander Haig announced "firm evidence" of the use of chemical weapons in Southeast Asia. But the evidence was based on the finding of trichothecenes in a single leaf. Because the State Department had no control sample, and no positive evidence about the natural occurrence of trichothecenes in Southeast Asia, its evidence appeared to be something short of compelling (*Science*, 2 October, p. 34).

The State Department's three new samples have been found to be positive for trichothecenes. In addition, controls collected for one set of samples have been shown to be negative. "We now have the smoking gun. We have four separate pieces of physical evidence," Burt announced at a hearing of the Senate arms control subcommittee on 10 November.

The symptoms reported by the refugees make a "perfect fit" with the symptoms caused by trichothecenes, Burt reported. Other pieces of evidence he cited include the fact that some research into mass production of trichothecenes has been done in Soviet institutes under military control. The Soviet Union is providing military assistance to Laos and Kampuchea and to the Vietnamese forces fighting there. Soviet chemical experts, Burt said, "have inspected a number of chemical weapons storage facilities there." Only the Soviet Union has the capacity to mass produce trichothecene toxins, he testified.

The State Department's case seems to many to be proved beyond question. The evidence of the four samples of yellow rain "leaves room for no conclusion except that Soviet-supplied biological warfare agents are being used in Asia," declared the *Wall Street Journal* in a threnodic editorial. Only one witness at the Senate hearing expressed any reservations. "In some respects I would recommend caution in concluding whether or not trichothecene toxins have been used, although I agree that the preliminary evidence indicates that they have been," said Harvard biologist Matthew Meselson.

It is hard to quarrel with a smoking gun of the sort that the trichothecenes have provided. Nevertheless, an accusation that the Soviet Union is breaking solemn treaties should be based on the best quality of evidence that the United States government is able to prepare. By this criterion, questions arise about the State Department's case and the way it has been presented:

- One of the four samples of yellow rain was collected by *Soldier of Fortune*, a magazine devoted to the affairs of mercenaries. Burt in his testimony made no distinction between the reliability of the three yellow rain samples in the government's possession and that collected by *Soldier of Fortune* magazine.
- Burt told the Senate committee that the chemical attacks had sometimes been conducted by an AN2—"a Soviet biplane used as a crop duster in the U.S.S.R." He neglected to observe that the AN2 is built in both an agricultural and a passenger configuration, and in its latter capacity is in regular service with the Laotian civil air force.
- Burt mentioned that the man returning one of the samples, water from a pond exposed to yellow rain, accidentally spilled some on himself, "and he arrived in Thailand gravely ill." The water sample was analyzed as containing 66 parts per million of the trichothecene toxin deoxynivalenol. According to calculations by Meselson, one would need to drink about 8 gallons of such a sample to receive a lethal dose: Meselson finds it difficult to see how exposure to a spill could make a man "gravely ill."
- Burt portrayed the alleged use of chemicals as "campaigns of mounting extermination which are being conducted in Laos, Kampuchea, and more recently in Afghanistan." In Laos, the principal targets are said to be the villages of the Hmong tribesmen, used as allies by the CIA during the Vietnam war. Although there is a U.S. embassy in Laos, the evidence presented at the Senate hearing came from interviews with refugees in Thailand. The State Department's belief in an extermination campaign against the Hmong is not verified by one American who has been inside Laos recently. From October 1979 until May of this year, Fred Swartzendruber was the representative in Laos of the Mennonite Central Committee. He traveled extensively in Laos to visit development projects, often asking about the chemical attacks which were being talked about so often in Bangkok. Swartzendruber told *Science* he could find no Hmong who knew of a chemical attack: apart from some fighting around Phu Bia mountain, there were not even any major hostilities during that period, he says. Some Hmong were leaving their villages, Swartzendruber says, but because they resented the government's attempt to impose civil control, including taxation.
- Burt told the Senate committee that yellow rain was so called because it "seemed to be made up of small particles, which would make sounds, when falling on rooftops or vegetation, similar to that made by rain." But how do particles of a size to patter on a rooftop succeed in delivering a fatal dose of toxin to a human? They are not an aerosol, so cannot be inhaled. Do they stick to the skin? That is not reported to be the case. Frederick Celic, a State Department expert on yellow rain, says he does not know by what mechanism the toxin is delivered to the body.
- Burt told the Senate committee that the trichothecene toxins produce in animals "all the symptoms I have mentioned [as occurring in the victims of

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yellow rain] and they are not known to produce any symptoms not reported." According to Burt, the victims experience itching and start to vomit increasing quantities of blood: "Within an hour, they would die, apparently of shock and the massive loss of blood from the stomach." But the State Department's own trichothecene expert, Chester Mirocha of the University of Minnesota, says that from his knowledge of animal experiments "I would have a difficult time explaining the rapid hemorrhaging" reported by the yellow rain victims. Mirocha finds that when pigs are injected with 1.25 milligrams per kilogram—the LD_{50} dose—of T2 trichothecene, they vomit and suffer paralysis of the hindquarters. There is no rapid hemorrhaging. "If they don't die within 12 hours, they will pull out of it," says Mirocha.

• The first yellow rain analyzed by Mirocha was a leaf and stem from a village in Kampuchea. The State Department gave him two pieces of leaf and stem, each weighing 0.2 gram. The amounts, in parts per million, of three different trichothecene toxins found in the two samples were as follows:

Toxin	Amount detected (ppm)	
	Sample A	Sample B
T2	3.15	35
Nivalenol	1.09	22
Deoxynivalenol	59.1	Not detected

Sample A and sample B, with their widely differing amounts of toxin, are two halves of the same leaf and stem. Mirocha, who was unaware of this until asked by *Science* for an explanation, says that variability is to be expected in nature. If the toxins were evenly mixed in the yellow rain, the two leaf halves should contain the same relative proportions of the toxins (except for T2: the State Department apparently spiked sample B with T2 as a test of the analytic procedure). The State Department's Celic suggests that the binding characteristics of the various toxins could cause them to degrade at different rates.

• The significance of the levels of trichothecene found in the samples has to be judged against a background of quite considerable ignorance about the natural ecology of the toxins. Almost all present knowledge of trichothecenes comes from studies of crop plants, in which the toxins are not found regularly. When the first accusations were made in September, a State Department fact sheet, referring to the levels found by Mirocha in the table above, stated that "Since normal

Fred Swartzendruber

Hmong growing opium poppies

Ban Ban, Laos, February 1981

background levels of these toxins are essentially undetectable, the high levels found are considered to be abnormal, and it is highly unlikely that such levels could have occurred in a natural intoxication. In point of fact, these mycotoxins do not occur naturally in Southeast Asia." The State Department has since modified the last statement, but the more general problem, according to Meselson, is that the normal background levels of trichothecenes in the natural ecology of Southeast Asia are simply unknown. The first attempt to look at trichothecenes in a noncrop plant was described only last month in *Science* (23 October, pp. 460 and 461). Bruce Jarvis and colleagues at the University of Maryland reported finding levels of 200 to 300 parts per million in a common Brazilian shrub.

• The three samples of yellow rain obtained by the State Department have the following origin. The leaf-and-stem sample and the water sample come from a village in Kampuchea, near the Thai border. A third sample, said to be from Laos, was scraped off a rock. The first two samples are more impressive scientifically because they have controls; two soil samples, and four of vegetation of the same species, were all found to contain no trichothecenes. The State Department declines to say what the species was or how it was identified. Celic also refuses to state who collected the samples. According to Sterling Seagrave, author of a recent book about yellow rain, Thai military provided some samples; a report in the Washington *Post* states that the Khmer Rouge supplied one of the others. How can the State Department be sure of the authenticity of its samples? "We are confident that the people collecting these samples did so on instructions and under training and are the kind of people we can rely on," says Celic. "You can make the argument that one or two samples might have been spiked. But now we have samples from different sources. If it were a hoax, you would pick something that is easier to identify. Also, T2 is commercially available but the other toxins are not."

• The Russians' motives for resorting to chemical warfare, if they have, are particularly hard to understand. For rather small, short-term gains, accruing not to themselves but their Vietnamese allies, they have run extraordinarily high risks if detected. Besides incurring international odium for unleashing novel forms of warfare on Third World populations, they would also severely damage relations with the United States by breaking treaty obligations which they have never been shown to violate. Why would the Russians engage in such apparently self-defeating behavior? According to the State Department's Gary Crocker, the chemical agents afford uniquely effective weapons against resistance movements in Laos, Kampuchea, and Afghanistan, three countries in which it is important for the Soviet Union to establish stable, pro-Soviet regimes. There was an excellent chance of avoiding detection, Crocker argues, because the agents were used in remote areas, and are hard to identify.

Perhaps what is most problematic with the State Department's case is the disparity between the present state of the evidence and the enormity of the consequences that would flow if the charges are true. To accuse the Russians of using Southeast Asia as a testbed for an arsenal of novel chemical weapons requires a higher standard of proof. Sociologically competent interviews with refugees, proof of the validity of samples, scientifically reputable statements on the natural ecology and symptomatology of tricothecenes—all are kinds of evidence that the State Department has the resources to prepare. Instead, it has gone public with a sketchily documented case, as if the desire to bespatter the Russians had outweighed a judgment to wait for a firmer case. The State Department is right to be concerned about the presence of novel toxins in the samples it has collected. The evidence already in hand is sufficient to suggest that a serious investigation of yellow rain should begin.

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