

Chapter 2

A History of the Development and Procurement of Tactical Herbicides

Since 1980, controversy has persisted over the locations at which the Department of Defense (DOD) may have used, tested or evaluated, the herbicides containing 2,4,5-T and its associated dioxin, and “other herbicides” used in the Vietnam War. Adding to the controversy is the confusion by the public, Vietnam veterans, and by the Department of Veterans Affairs as to the distinction between “commercial herbicides” purchased by the DOD and “tactical herbicides” developed by the DOD. Contrary to historical records, many individuals thought that commercially available herbicides were purchased directly from the chemical companies and deployed to the battlefields in Vietnam. However, the use of commercial herbicides was under the jurisdiction of the Armed Forces Pest Control Board (subsequently the Armed Forces Pest Management Board), Forest Glen Station, Walter Reed Army Medical Center, Bethesda, Maryland. The uses and application of commercial herbicides were the responsibilities of the Base Civil Engineers, while tactical herbicides were under the control of special military units (e.g., Army Chemical Corps, and the 7th Air Force’s 12th Special Operations Squadron) specifically trained to handle and apply them in hostile military environments. The history of the military development and use of tactical herbicides dates to World War II. The lead agency in developing and testing these tactical herbicides was the US Army Chemical Corps Research Laboratories at Fort Detrick, Maryland. This Chapter describes the development and procurement of the tactical herbicides used in Vietnam.

2.1 Background

In early 2006, the Department of Veterans Affairs (DVA) requested that the Department of Defense provide: “an official compilation of locations and dates outside of Vietnam where the Department used herbicide agents, including Agent Orange, as well as locations and dates where DOD personnel were likely exposed to these agents.” The intent of this request was to obtain information

that may be important in evaluating the merits of many veterans' disability claims. In response to the DVA request, the Office of the Under Secretary of Defense (Installations and Environment) commissioned the report "The History of the US Department of Defense Programs for the Testing, Evaluation, and Storage of Tactical Herbicides" (Young 2006). This report discussed the history of the development of the tactical herbicides, how they differed from commercial herbicides, and where they were tested, evaluated, stored, and used (in the case of Korea in 1968) **OUTSIDE** of Vietnam. Additionally, the report discussed the final disposition of Herbicide Orange after Vietnam. The report contained 32 leaflets identifying different locations or multiple locations involved in same projects (e.g., Leaflet 19 identified 5 locations in Texas), or the multiple use of a specific location (e.g. Eglin Air Force Base, Florida). A total of 40 distinctly different locations were identified. For each leaflet, a description of the activity was provided, an assessment was made of the activity, and where identified, the individuals involved in the project, and sources documented (Young 2006). The Department of Defense was thorough and detailed in the procedures for the safe and efficacious use of tactical herbicides in military operations.

2.2 The Initial Development of Tactical Herbicides

The period of use of tactical herbicides in the Vietnam War, 29 December 1961–31 October 1971, is a story that begins many years before Vietnam. It is really a history of the Department of the Defense's efforts to develop vegetation control methods that would have military applications. In 1943, the Department of the Army contracted the University of Chicago to study the effects of a new series of organic compounds, especially 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) on cereal grains and broadleaf crops (Irish et al. 1969). From that research came the concept of military applications of small quantities of such compounds to destroy enemy crops. Subsequently, in early 1945, the Army tested 2,4-D and 2,4,5-T formulations at the Bushnell Army Air Field in Florida (Carpenter 1945). That site is now a FUDS (**F**ormerly **U**sed **D**efense **S**ite) location for the Department of Defense. Although not used in World War II, the concept of vegetation control was not forgotten. In 1952, the Department of Army's Chemical Corps Biological Laboratories at Camp Detrick, Maryland, initiated a major program to develop both the aerial spray equipment and herbicide formulations for potential deployment in the Korean Conflict. Again, although not used in the Korean Conflict, the equipment that had been developed and tested, and the formulated chemicals were both stored on the Island of Guam until the end of the Conflict, after which the equipment was sent to Utah and the drums of herbicide were sent to Camp Detrick. Camp Detrick (now Fort Detrick) where the Army Chemical Corps scientists continued working on developing deployment systems and herbicidal materials through the 1950s (Irish et al. 1969).

2.2.1 Previous Research Supporting the Initial Deployment of Tactical Herbicides in Vietnam

The Tactical Herbicide Spray Systems (primarily fixed-wing, helicopter, and truck-mounted sprayers) developed from 1945 to 1959 were available to be tested in Vietnam in late 1961. Their successful use during the period from 8 October 1961 through 18 March 1965 (the Initial Program Development Phase in Vietnam) resulted in the United States Department of Defense approving a major combat role for tactical herbicides from 29 March 1965 to 7 January 1971 (the Operational Phase). The Initial Program Development Phase depended heavily on the limited research into both aerial spray systems and tactical herbicides that the United Army Chemical Corps had carried out from the end of World War II (1945) through 1959. Eight locations were identified and are briefly described below:

1. *Bushnell Army Air Field, Florida, February – April 1945.* The vegetation on a total of 155 hectares (382 acres) were evaluated following aerial applications of a 2% solution of 2,4-D and 2,4,5-T in tributyl phosphate and diesel fuel. The formulations were prepared at Fort Detrick and transported to Bushnell Air Field (Carpenter 1945; Norman et al. 1945; Young 2006).
2. *United States Department of Agriculture (USDA) Research Station, Brawley, California, July–August 1951.* In cooperation with USDA, the Army Chemical Corps evaluated formulations of 2,4-D and 2,4,5-T on small field plots of various agronomic crops in an effort to evaluate the anti-crop effectiveness of small droplet sprays of 2,4-D and 2,4,5-T (Weintraub and Minarik 1952; Young 2006).
3. *Eglin Air Force Base, Florida (Test Ranges 52 and 57), November 1952–April 1953.* In preparation for the potential deployment of anti-crop agents, the Air Force Armament Center evaluated a Large Capacity Spray System (MC-1 Hourglass System) in the B-29, B-50 and C-119 bomber aircraft spraying a mixture of technical normal butyl 2,4-D (50%), technical normal butyl 2,4,5-T (50%) prepared by the Army Chemical Corps. The spray tests were conducted on 3,520 hectares (8,700 acres) from an altitude of 300–600 m, releasing a total of 2,245 l (Acker et al. 1953; Ward 1953; Hanson, 1965; Young 2006).
4. *USDA Experimental Fields, Gallatin Valley, Bozeman, Montana, July–November 1953.* The US Army Chemical Corps evaluated small quantities of various 2,4-D and 2,4,5-T formulations as to their effectiveness as anti-crop agents against wheat. The tests were conducted on approximately 55 hectares of hard red spring wheat (Acker et al. February 1954a; Young 2006).
5. *Area B, Fort Detrick, Frederick, Maryland, June–July 1953.* US Army Chemical Corps scientists evaluated the 3:1 mixture of technical normal butyls of 2,4-D and 2,4,5-T on plots of soybeans and sweet potatoes by simulating tactical operational conditions by spraying from a 6-m tower mounted on a pickup (Acker et al. January 1954b; Young 2006).
6. *Fort Ritchie, Cascade, Maryland, April 1956–September 1957.* The US Army Chemical Corps evaluated 577 potential herbicidal chemicals, including both

phenoxy and arsenical formulations. The chemicals were applied by hand applications to small field plots (Preston et al. 1959; Young 2006).

7. *Dugway, Utah, May 1951–March 1959*. The US Army Chemical Corps and the US Air Force conducted a series of spray tests and evaluations from a variety of platforms including balloons, towers, light aircraft, and jet aircraft with a range of volumes from low volumes to large capacity spray tank volumes. Studies were conducted on the effects of altitude and airspeed on the various potential tactical herbicides (King and Ward 1961; Young 2006).
8. *Fort Drum, New York, May–October 1959*. In the summer of 1959, thirteen drums (2,700 l) of the Herbicide Purple formulation were aerially applied by helicopter to approximately 1,035 hectares of Fort Drum's deciduous forested areas. The US Army Chemical Corps conducted the test and the Herbicide Purple was surplus herbicide manufactured in the 1952 period (Brown 1962; Minarik 1964; Buckingham 1982; Young 2006).

Following the successful tests at Dugway, Utah and at Fort Drum in New York State, the US Army Chemical Corps determined that the capability of deploying tactical herbicides in a combat environment was possible (Buckingham 1982). The tests and evaluation of the herbicides had resulted in the selection of formulations of 2,4-D and 2,4,5-T as defoliants, and of the organic arsenicals as potential anti-crop herbicides, especially against grains (e.g., rice). The selection of the appropriate aircraft and the training of the aircrews would depend upon the mission (Cecil 1986). The role of the Air Force Special Aerial Spray Flight, the Air Force Unit responsible for the aerial spraying of insecticides, and its adoption and modification of the C-123 "Provider" as the aircraft of choice containing the 1,000-gal MC-1 Hourglass Large Capacity Spray Tank and pump systems, has been extensively described (Buckingham 1982; Cecil 1986).

Cecil described the deteriorating situation in Indochina, and the decision by President John Kennedy in May 1961 to jointly establish the United States/Vietnamese Combat Development and Test Center (CDTC) in Vietnam, under the direction of the Defense Department's Advanced Research Projects Agency (ARPA) (Cecil 1986). The first task of the CDTC was to evaluate the use of herbicides to destroy concealing vegetation and enemy food supplies (Project AGILE) (Cecil 1986). To undertake this task in 1961 meant that the men, equipment, and chemicals had to be rushed to Vietnam to take advantage of the growing season, which would end in September or October. As Cecil described it: "...much of the equipment used in the initial tests was 'what was available,' rather than 'what was ideal'" (Cecil 1986).

2.2.2 The Selection of the First Tactical Herbicides for Use in South Vietnam

Under Project AGILE, the Department of Army's Biological Laboratories at Fort Detrick, Maryland were given the responsibility to determine the technical

feasibility of defoliating jungle vegetation in South Vietnam. The Fort Detrick scientists had been involved in 1957 with tests showing the herbicidal activity of cacodylic acid (an organic arsenical) on rice and grasses, and in the 1959 aerial applications tests with mixtures of 2,4-D and 2,4,5-T at Camp Drum, New York (Darrow et al. 1966). As part of Project AGILE, a contract was negotiated in 1962 with the Institute for Defense Analyses, Washington DC to do an in-depth analysis of the available literature on “Chemicals for Control of Vegetation” (Coates and Sharpe 1963). The Institute concluded that the selection of chemicals should be evaluated on the basis of plant physiology (how they physiologically affect the plant); on the basis of health and safety; and, on performance characteristics of commercially available phytoactive chemicals (Coates and Sharpe 1963). The Institute identified five principal military applications for anti-vegetative agents:

- Roadside clearance to reduce ambush,
- Boundary demarcation,
- Vegetation control in depot areas,
- Area denudation to uncover selected targets and to reveal enemy hideouts, and
- Aquatic weed control (Coates and Sharpe 1963).

They reasoned that three distinct phytochemical activities were required, namely the rapid reduction in foliage by desiccation; the systemic herbicidal activity to kill the plants; and residual herbicidal action in the soil to prohibit or retard growth. They concluded that no single herbicidal agent would bring about all three effects; it was essential to consider the use of mixed or formulated herbicides, applied together or successively (Coates and Sharpe 1963).

As a result, the tentative choice of tactical herbicides for use in Vietnam was based upon proven performance in both military and commercial situations, availability in large quantity, costs, and known or accepted safety in regard to their toxicity to humans and animals (Irish et al. 1969). Figure 2.1 illustrates the use, extent, and importance of 2,4,5-T herbicide for the control of brush on communication right-of-ways in the US. Simultaneously, the Army Chemical Corps at Fort Detrick were investigating research into the disseminating characteristics affecting aerosol stability (Trout 1962). Studies of the evaporation rate of n-butyl 2,4-D represented the first work of this nature performed on this herbicide. This research provided critical information as to the size of particles that would be required if the aerial spraying of n-butyl formulations of the phenoxy herbicides were to be effective as defoliants (Trout 1962).

On 10 August 1961, as part of Project AGILE, Fort Detrick personnel initiated defoliation tests in South Vietnam (Brown 1962). Stocks (10 drums–1,900 l) of the commercial herbicide “Dinoxol” had arrived on 17 July 1961. It was the first herbicide to be evaluated. It was aerially sprayed using an H-34 helicopter equipped with the HIDAL (Helicopter Insecticide Dispersal Apparatus, Liquid) system. Dinoxol consisted of 20% 2,4-D as the butoxy ethanol ester, and 20% 2,4,5-T butoxy ethanol ester. On 4 September 1961,



Fig. 2.1 Clearing of lines of communication. The effectiveness of 2,4,5-T Herbicide is shown in these two photographs taken in 1959 before and six months after application with a commercial ester formulation of 2,4,5-T (Photographs courtesy of The Dow Chemical Company, Midland, Michigan)

2,025 l of “Trinoxol” (40% 2,4,5-butoxy ethanol ester) arrived and was immediately evaluated (Brown 1962). On 20 November 1961 Pink, Green, and a powdered formulation of Blue (Ansar) arrived. The first shipment of Purple arrived on 9 January 1962 (Brown 1962). Between 10 August 1961 through 3 February 1962, 18 tests were conducted using the six different herbicide formulations. Tests conducted after 9 January 1962 involved the use of modified C-123 aircraft deployed to Vietnam under the code name “Operation RANCH HAND” (Brown 1962; Cecil 1986). At the conclusion of the tests, the recommendation was that Purple, Pink, and Green should be used the tactical herbicides of choice for large scale use (Brown 1962).

In 1950, more than 4.5 million kilograms of the phenoxy herbicides were used annually for weed and brush control in the United States. By 1960, in excess of 16 million kilograms were used (Peterson 1967). Thus, it was not surprising that the first tactical herbicides to be used in Vietnam were based on the research, testing, and evaluations of 2,4-D and 2,4,5-T formulations (Crafts 1968).

As noted, the first three tactical herbicides deployed for use in Vietnam were code named Herbicides Purple, Pink, and Green, all of which contained 2,4,5-T.

As noted from Table 1.1, Chapter 1, 365 drums (75,920 l) of Herbicide Green; 1,315 drums (273,520 l) of Herbicide Pink; and 12,405 drums (2,580,240 l) of Herbicide Purple were used in Vietnam from late 1961 through mid-1965 (Young et al. 2008). The fourth tactical herbicide deployed to South Vietnam was a powdered commercial formulation of cacodylic acid (or Ansar 138®).

Herbicide Purple was first formulated in early 1950s in anticipation of use in the conflict in Korea and the possible need for vegetation-control systems. Purple was selected as the agent of choice in 1951, and by 1952 the first spray device, the MC-1 or Hour-glass System was released for prove out and acceptance testing. During 1953 operational capability was completed and the herbicide and spray system was deployed to Guam for anticipated use in the Korean Conflict, although it was never used. At the close of the Korean Conflict (1955) much of the stockpile of Purple was disposed of and the spray units placed in storage (Irish et al. 1969). Purple was approved for military procurement on 27 January 1953 (Department of Army, 1970). Purple was formulated to contain 1.04 kg/l of the active ingredients 2,4-D (510 g/l) and 2,4,5-T (530 g/l) (Darrow et al. 1966). The percentages of the formulation were:

- n-butyl 2,4-D 50%
- n-butyl 2,4,5-T 30%
- iso-butyl 2,4,5-T 20%

Although the records were not complete, it appeared that in 1961 at least a portion of remaining stocks of Purple removed from Guam in 1955 and stored at Fort Detrick were sent to Eglin AFB, Florida, for use in the test and evaluation programs of the spray equipment for use in Vietnam (Young 1974). Subsequent Purple was purchased in FY (Fiscal Year) 1961–FY 1964 (calendar year 1962–1965) for use in Vietnam.

Herbicide Pink was a formulation of 2,4,5-T used extensively in the early RANCH HAND operations (Brown 1962; Collins 1967), and in the defoliation test programs of 1963 in Thailand (Darrow et al. 1966). Pink was formulated to contain 971 g/l active ingredient 2,4,5-T. The percentages of the formulation were:

- n-butyl 2,4,5-T 60%
- iso-butyl 2,4,5-T 40%

The first mission spraying Herbicide Pink was on 29 December 1961 “(the first use of an approved ‘tactical herbicide.’)” A C-47 aircraft with modified spray equipment was used to spray the herbicide north of Route 15 between Bien Hoa and Long Thanh. Three passes over a test site disseminating a total of almost 200 l of concentrated Pink formulation resulted in a rating of “poor” (Brown 1962). It appeared that the deposition was sublethal, and although the swath was visible in the first week, it failed to develop with time (Brown 1962).

Herbicide Green was a single component formulation consisting of the n-butyl ester of 2,4,5-T. It was used in limited quantities in 1962. Green contained 971 grams/liter active ingredient 2,4,5-T [Brown 1962]. After arrival of the Green Herbicide in November 1961, apparently all of it was

mixed with Pink or Purple and used in early RANCH HAND missions [Brown 1962; Darrow 1967].

Herbicides Purple, Pink, and Green were shipped to Vietnam (Tan Son Nhut, RVN) in 208-liter drums. To distinguish the herbicides, a 30-cm color-coded band was painted around the center of each drum. Unfortunately, the pink and purple bands were hard to distinguish between each other, especially after they had been stored in the open and in a tropical environment. Consequently, early RANCH HAND mission records frequently misidentified Pink and Purple (Darrow 1967; Cecil 1986). This confusion continued when the HERBICIDE REPORTING SYSTEM, HERBS, was implemented in 1970.

First Herbicide Blue was a powdered form of a commercial formulation of cacodylic acid known as “Ansar 138®”. Approximately 6,800 kg of Ansar arrived in Vietnam on 20 November 1961. Water was required to prepare the formulation for spraying (estimated total volume with the 6,800 kg was 95 drums). The first mission of powdered Blue was 29 December 1961 and it was sprayed from a Buffalo Turbine at 10 km/h along a single-track road near an airstrip 6 km from Long Thanh (Brown 1962). The Blue Herbicide caused responses that indicated a relatively rapid desiccation of the foliage to an extent that warranted an aerial release (Brown 1962). The commercial formulation of Ansar 138® was an arsenical herbicide containing 65.6% cacodylic acid, and was manufactured by the Ansul Company, Marinette, Wisconsin.

These four tactical herbicides were used during the period from 29 December 1961 through 18 March 1965 (the Initial Program Development Phase in Vietnam). This period was a time when the aircrews of Operation RANCH HAND had the opportunity to become familiar with the weather and terrain of South Vietnam, and for developing the operational tactics and doctrine (Cecil 1986). It was period for evaluating and upgrading the aircraft and the spray systems that were constantly being developed and tested at Eglin AFB, Florida. It was also a time of deciding how missions would be assigned and how the aircraft and crews would be protected from the increasingly hostile ground fire encountered during the missions. As Cecil noted:

At the beginning of 1964 the herbicide concept was merely a small adjunct of questionable value to the US effort in Vietnam. By the end of the year the RANCH HAND mission was not only accepted by the military but eagerly sought after, with sortie demands exceeding capacity. While not all questions had been answered, or all problems solved, the foundation for continued development had been laid. Western public comment had been negligible, and the outburst of scientific and lay criticism of the herbicide program was still in the future; 1964 had been a year of development and preparation for continued growth (Cecil 1986).

The role of the United States changed during 1965 from an overt role of training and supplying the South Vietnamese armed forces to a direct combat participation on a major scale (Cecil 1986). This action resulted in the United States Department of Defense approving a major combat role for tactical herbicides, namely the “Operational Phase” of Operation RANCH HAND, a phase that started on 29 March 1965 and ended on 7 January 1971. In

anticipation of a potential major operational role for tactical herbicides, the US Army Chemical Corp never faltered in its planning and preparation for that mission.

2.3 The Defoliation Conferences

In 1962, the US Army Chemical Corps' Biological Laboratories at Fort Detrick, Maryland invited "essentially" the entire pesticide industry to Fort Detrick and briefed them on the technical and contract aspects of a Military-Industry Defoliation Program. The intent of this military-industry contract partnership was to "demand of industry its ability, creative ideas, facilities, and the competence of its scientific and engineering disciplines to achieve the results needed in the shortest possible time", i.e., to develop chemicals that could attack vegetation in order to destroy the cover and concealment of enemy combatants in South Vietnam (Hayward 1964). The desired characteristics of an effective defoliant were the following:

- Broad spectrum of activity: the agent should be active on many kinds of plants and vegetation with emphasis on woody species;
- Rapid in action: the physical changes that result in defoliation or leaf abscission must take place within a three-day period;
- Suitable for application with air or ground equipment: Agent should be preferably in liquids of high concentration;
- Nontoxic to man and animals: compounds of moderate or high toxicity may be included in the screening program on the basis that highly favorable candidates may be modified through formulation or other methods to minimize hazards of toxicity;
- Stable in storage: light-sensitive compounds or other unstable chemicals should be examined, since suitable formulations of such compounds that are found to be active may insure stability;
- Effective in low dosages: screening programs have shown a number of synthesized compounds to have high activity as defoliants, desiccants, and herbicides at 112 g/ha;
- Inexpensive: cost should not be a factor in the initial consideration of candidate compounds;
- Readily available or capable of manufacturers: complexity of initial synthesis efforts should not eliminate consideration of a candidate chemical; and
- Noncorrosive: Some of the more active commercially available desiccants require special handling in current application equipment. Proper formulation may eliminate such hazards of corrosive action on equipment (Darrow 1965a).

In late July 1963, Fort Detrick sponsored the First Defoliation Conference. Industrial researchers from American Cyanamid, Ansul Chemical Company, Dow Chemical Company, Ethyl Corporation, FMC Corporation, General

Aniline & Film Corporation, Hooker Chemical Corporation, Monsanto Research Corporation, Pennsalt Chemicals Corporation, and US Rubber Company participated and many of them presented their laboratory, greenhouse, and field studies (as available) of potential candidate defoliant (Mattie 1964). Ansul Company presented their program on the synthesis and preparation of arsinic acids (Ehman 1964). The Dow Chemical Company presented a paper on "Tordon Herbicide for Vegetation Control." describing Dow's results from Tordon (picloram) field studies conducted at Davis, California; at Greenville, Mississippi; and, at Midland, Michigan (Wiltse 1964). Field experiments indicated that as a spray picloram was 4 times was more effective on a kg/liter basis than 2,4,5-T and 2,4-D on a number of woody plants, and as a soil treatment picloram was 8 times more effective on a kg/hectare basis than Fenuron. Moreover, the toxicological studies conducted by Dow indicated that picloram herbicide was safe to handle and presented no hazards to men or animals when used as directed (Wiltse 1964). These data greatly interested the researchers from Fort Detrick.

The following year at the Second Defoliation Conference in August 1964, three research projects involving picloram were presented and discussed. The first project was a presentation by The Dow Chemical Company on the "Effects of Tordon on Crops" (Watson and Barrons 1965). The results showed that picloram was highly injurious when applied to nongraminaceous crops, i.e., such broadleaf crops as manioc and sweet potato, and at doses far below those required for significant yield reductions from 2,4-D and 2,4,5-T. Moreover, soil residual tests confirmed that the effects of picloram were evident for nine weeks after soil applications (Watson and Barrons 1964). The second research project was a presentation by the Agricultural Research Service, United States Department of Agriculture (USDA) under contract to the Army Chemical Corps, on "Control and Defoliation of Vegetation" (Klingman 1965). This research involved field trials of candidate herbicides including picloram that had been applied to field plots in October 1963 in Livingston and Llano, Texas, and to forest plots in Guanica, Maricao, and Luquilla, Puerto Rico. In Texas and in Puerto Rico, the potassium salt of picloram provided the highest overall defoliation following aerial applications at rates of 2.25 or 2.5 kg/ha (Klingman 1965; Tschirley 1968). Fort Detrick's Crop Division presented the third project. It involved the use of the candidate defoliant on field plots of broadleaf trees on Fort Ritchie and Fort Meade (both in Maryland), and field trials in Georgia (approximately 26 ha of powerline right-of-ways) and Tennessee (approximately 26 ha of Tennessee Valley Authority powerline right-of-ways) (Demaree 1965). The picloram formulations included Tordon (potassium salt), Tordon + 2,4-D, Tordon + diquat, and Tordon + endothal. Excellent results were obtained with Tordon + 2,4-D (subsequently labeled as Tordon 101 containing the triisopropanolamine salt of picloram and 2,4-D) (Demaree 1965).

The first evaluation of "Orange Herbicide" occurred in the 1963 field trials at Fort Ritchie, Maryland (Demaree 1965). Herbicide Purple and a liquid formulation of cacodylic acid were also included in these tests (Demaree 1965).

Subsequently, Herbicides Orange and Purple were included in the tests in Georgia, Tennessee, and in field tests in Maryland (Demaree 1965). The Maryland tests were conducted at Aberdeen Proving Grounds, and their purpose was to test the seasonal variations of five different formulations of proposed tactical herbicides, including Herbicides Orange, Purple, picloram (Tordon 101), and cacodylic acid (Phytar 560, subsequently "Tactical Herbicide Blue") (Demaree 1965). While Fort Detrick was conducting these tests in the United States, arrangements were made with the Thai government to conduct some defoliation tests on the Pranburi Military Reservation in Thailand. During the period from April through September 1964, approximately 435 l of Purple, 165 l of Pink, and 60 l of Blue were aerially sprayed on approximately 70 ha of the Pranburi Reservation (Darrow 1965b; Young 2006). The evaluation of these tests 6 months after application confirmed that the 2,4-D/2,4,5-T combinations of butyl esters were superior to other herbicides, although Blue was an effective rapidly acting desiccant (Darrow 1965c).

The Third Defoliation Conference was held in August 1965 and the presentations focused on the successful field trials in Maryland, Georgia, Tennessee, Texas, and Puerto Rico (Mattie and Darrow 1966). The effectiveness of Tordon 101 to kill white pine, short-needle pine, and scrub pine but not damage red cedar or cause permanent damage to ash, hickory, or rhododendron provided amply justification to move this formulation into the category of a "Tactical Herbicide" and to receive the name "Herbicide White" (Young 2006). The consequence of this action removed Tordon 101 from receiving a "Federal Specification" (issued by the General Services Administration) that would have allowed US Air Force, Army, or Navy Installations to purchase the herbicide for use on military lands. Instead, Tordon 101 received a "Military Specification" that allowed the Department of Defense (via the Defense Supply Agency) to directly purchase the herbicide for use ONLY in combat operations in South Vietnam. The selection and use of the tactical herbicides were exempt from USDA regulatory oversight, or from the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Young 2006).

Of particular importance, the Agricultural Research Service scientists studied the penetration and distribution of herbicide sprays through forest canopies in Texas and Puerto Rico (Tschirley 1968). Although the two areas were widely separated geographically, the forests were similar in terms of structure. The test site in Puerto Rico was typical of moist forest formations. The lowest level of vegetation ranged from 2 to 3 m; the intermediate level had a mean height of 9 m; and, the upper canopy had a mean height of >15 m. In Texas, the forest had a dense and relatively unbroken over-story of post and blackjack oak about 12 m in height. The youpon undercanopy also was dense and relatively unbroken and was about 5 m in height. The volume of spray reaching lower sampling levels varied proportionally with the amount deposited on the top line above the canopy. On the average, about 21% of the spray volume penetrated the upper canopy and about 6% penetrated to the ground level in the experiments conducted in Texas and Puerto Rico (Tschirley 1968).

With the selection of the new “Tactical Herbicides White and Blue”, the US Air Force Air Development and Test Center at Eglin AFB, Florida initiated tests evaluating the aerial dispersal characteristics of the herbicide, and its compatibility with the UC-123 aircraft and the AA 45Y-1 Internal Defoliant Dispenser (Flynn 1964). These tests involved the spraying of more than 75 drums of Herbicide White (15,780 l), containing 1,020 kg active ingredient picloram, and 80 drums (16,640 l) of Herbicide Blue containing 6,180 kg of cacodylic acid (Young 1974). Additional tests at Eglin AFB showed that 87% of the herbicide impacted the glass plates on the test array within one minute and within or near the spray swath (Harrigan 1970). The remaining 13% of the herbicide took longer (up to 3 min) to settle due to vortices at the wing tips, drift, or evaporation (Harrigan 1970). Bio-monitoring around the test site confirmed that little lateral movement as spray drift occurred (Young 1974).

Although the decision to accept picloram as a component of a tactical herbicide (Tordon 101 as Herbicide White) occurred in late 1965, the Director of the Fort Detrick Biological Laboratories still had concerns. In a July 20th, 1966 note, Dr. C.E. Minarik stated:

Picloram, the proprietary component of Tordon 101, is a very active herbicide and in experiments conducted by the Crops Department personnel has proved to be as active as or more active than phenoxy type herbicides on a pound for pound basis.

However, the lack of data on the effectiveness of Tordon 101 mixture, at low volume rates, the higher costs per acre, and its slow response raise doubts as to the advisability of recommending its use on an operational scale in RVN at the present time. Additional R&D is required and is being conducted by Crops Department personnel during the current season. Preliminary results should be available in September 1966 and final results by June 1967 (Minarik 1966).

Thus as directed, the 1966 defoliation tests at Base Gagetown, New Brunswick, Canada involved the evaluation of the Tordon 101 formulation (White), Tordon 22 K (potassium salt of picloram), and formulation M-2993 (a 1:4 mixture of the isooctyl ester of picloram + the propylene glycol butyl ether ester of 2,4,5-T) in various combinations and rates. The tests also included different rates of Phytar 560 (liquid cacodylic acid formulation). In the 1967 tests, picloram was combined with paraquat or diquat. In general, the presence of picloram enhanced the defoliation performance of the 2,4,5-T, the 2,4-D, the paraquat, or the diquat (Demaree and Greager 1968; Demaree and Haws 1968). The 1966 tests at Base Gagetown also included the tactical herbicides Purple and Orange. In 1966, approximately 1 drum (~200 l) of Purple and 1 drum of Orange (~200 l), and a combination of 70% 2,4-D and 30% 2,4,5-T (~190 l) were sprayed on duplicate plots ranging from 9 to 28 l/ha (Demaree and Creager 1968). The 1967 tests at Gagetown involved the spraying of Herbicide Orange at 28 l/ha on duplicate plots for a total of ~ 70 l (Demaree and Haws 1968).

In July 1966, the newly named “Plant Sciences Laboratories” at Fort Detrick initiated a comprehensive short-term project to evaluate desiccants

and herbicidal mixtures as rapid-acting defoliants. The tests included 9 different desiccants including the tactical herbicide Blue, and a mixture of systemic herbicides including the two tactical herbicides Orange and White (Darrow et al 1971). The tests were conducted on lands at Fort Gordon near Augusta, Georgia; Fort Chaffee and Fort Smith in Arkansas, and on Forest Service lands in the Apalachicola National Forest near Sopchoppy, Florida (Darrow et al 1971). The results confirmed the choices of Blue, White, and Orange as tactical herbicides. In the 1967 defoliation tests on the Island of Kauai, Hawaii similar observations were obtained (Suehisa et al 1968; Young 2006).

During the three years spanning the three “Defoliation Conferences, ten primary contractors (Table 2.1) supplied 6,535 compounds for the defoliation screening program (Frank 1966). The assay plant used in the “Primary Defoliation Screening” was the 14-day-old Black Valentine bean. To be classed as “active” in the test, a compound had to exhibit herbicidal activity within 14 days after treatment with rates from 0.112 to 1.12 kg/ha.

The “Secondary Defoliation Screening” was conducted on seven species of 2- to 3-year- old seedling trees (Fig. 2.2) (Frank 1966). The hand applicator used in the initial screening test was a specially calibrated hand sprayer (Fig. 2.3).

The goal in these programs was the search for rapid-acting defoliants and desiccants that were active at low rates on all vegetation types (Frank 1966). Desiccants were usually evaluated on grass plots (Fig. 2.4) (Frank 1966).

The next step for the most successful defoliant or desiccant candidates was from the screening programs to the numerous field tests conducted throughout the United States, Puerto Rico, Canada, and Thailand, as previously noted.

Table 2.1 Number and percentage of chemicals from synthesis contracts active in “primary defoliation screening” (Frank 1966)

Contractor	Compounds		
	Number submitted	Number active on beans	% Active
American Cyanamid Company	56	10	18
Ansul Chemical Company	82	45	55
Dow Chemical Company	129	5	4
Ethyl Corporation	1,303	170	1
FMC Corporation	175	59	34
General Aniline & Film Corporation	67	16	24
Hooker Chemical Corporation	128	43	34
Monsanto Research Corporation	2,183	331	15
Pennsalt Chemicals Corporation	2,288	382	17
US Rubber Company	124	20	16
Total	6,535	1,081	



Fig. 2.2 The “Secondary Defoliation Screening” was conducted on 2- to 3-year-old on Norway Spruce, Eastern Hemlock, Chinese Elm, Black Locust, Red Maple, Pin Oak, Scotch Pine, and California Privet (Frank 1966). Photograph of the Seedling Nursery, Fort Deterick, Frederick MD in 1970 (photograph courtesy of A. Young)



Fig. 2.3 A 1970 photograph of the hand applicator used in the initial defoliant screening tests at Fort Detrick. The sprayer was a specially calibrated unit capable of delivery less than 0.1 kg/ha of candidate defoliants (photograph courtesy of A. Young)



Fig. 2.4 The screening at Fort Detrick of rapid acting desiccants was accomplished in small test plots of various grains and grasses (1970 photograph courtesy of A. Young)

2.4 The Major Three Tactical Herbicides Used in Vietnam

All of the field tests and evaluations ultimately resulted in the decision by both the US Army Chemical Corps' Plant Sciences Laboratories, and the US Air Force Logistics Command's San Antonio Air Materiel Area to select and purchase for use in Vietnam the tactical herbicides Orange, White, and Blue (Irish et al. 1969; Craig 1975).

Herbicide Orange was a reddish-brown to tan colored liquid, soluble in diesel fuel and organic solvents, but insoluble in water (Irish et al. 1969]. One liter of Herbicide Orange theoretically contained 510 g of the active ingredient of 2,4-D and 530 g of the active ingredient of 2,4,5-T, for a total of 1.04 kg/l. Herbicide Orange was formulated to contain a 50:50 mixture of the n-butyl esters of 2,4-D and 2,4,5-T. The percentages of the formulation typically were as follows:

- n-butyl ester of 2,4,-D 49.49 %
- free acid of 2,4-D 0.13 %
- n-butyl ester of 2,4,5-T 48.75%
- free acid of 2,4,5-T 1.00%
- inert ingredients (e.g. butyl alcohol and ester moieties) 0.62%

Herbicide Orange was first introduced in South Vietnam 1 March 1965 when it was used to defoliate portions of the banks of the Saigon River from the capitol city to the South China Sea (Cecil 1968). In 1986, the demand for and use of Herbicide Orange outstripped the ability of the US Department of Defense to

purchase it. Part of the problem was the availability of the n-butyl formulation; hence “Orange II” (two Orange 7.6-cm bands around the drum, while Orange had a single 7.6-cm band; the band width changed from 30 to 7.6 cm with the purchase of herbicides in FY 1964 (Young et al. 1978). The physical, chemical, and toxicological properties of Orange II were similar to those of Orange with the difference being the substitution of the iso-octyl ester of 2,4,5-T in Orange II for the n-butyl ester of 2,4,5-T in Orange. While Orange was formulated to contain 1.04 kg/l active ingredients 2,4-D and 2,4,5-T, Orange II was formulated to contain 0.911 kg/l (510 g/l 2,4-D, and 410 g/l 2,4,5-T) (Department of Army 1970). Thompson-Hayward, Kansas City, Kansas, was the only company to produce Orange II. Approximately 3.6 million liters of Orange II were shipped to South Vietnam during 1968 and early 1969 (Craig 1975).

Herbicide White was a dark brown viscous liquid that was soluble in water but insoluble in organic solvents and diesel fuel (Irish et al. 1969). One liter of Herbicide White contained 65 g of the active ingredient of 4-amino-3,5,6-trichloropicolinic acid (picloram) and 240 g of the active ingredient of 2,4-D. Herbicide White was formulated to contain a 1:4 mixture of the triisopropanopamine salts of picloram and 2,4-D. The percentages of the formulation were as follow:

triisopropanolamine salt of picloram 10.2%
triisopropanolamine salt of 2,4-D 39.6%
inert ingredient (primarily the solvent triisopropanolamine) 50.2%

Limited quantities of “White”, developed by Dow Chemical Company, arrived in Vietnam in December 1965 for evaluation. A mid-1966 shortage of Orange forced the use of large quantities of White by RANCH HAND before the Army Chemical Corps evaluations were completed, although the White was both slower acting and more expensive than Orange (Cecil 1986).

Herbicide Blue was first applied to a powdered cacodylic acid that contained 65% active cacodylic acid and 30% sodium chloride. It was mixed with water in 208-l drums prior to application [Darrow et al. 1966]. Herbicide Blue was a foliage-applied contact herbicide (desiccant) that was first tested by Fort Detrick scientists in 1955–1957 for its effectiveness against rice and other grasses (Department of the Army 1970). In late 1965, the first liquid formulation of sodium cacodylate as Herbicide Blue was procured and sent to Vietnam, and subsequently used in defoliation missions in January 1966 (Department of the Army 1970). The liquid formulation was a commercial product developed by Ansul Company as identified as Phytar 560. The purchase of this formulation with the additional surfactant identified it as “PHYTAR 560G”, and as a tactical herbicide with a “Military Specification” (Young and Wolverton 1970). Herbicide Blue was a clear yellowish-tan liquid that was soluble in water, but insoluble in organic solvents and diesel fuel (Irish et al. 1969). One liter Blue contained 370 g of the active ingredient hydroxydimethyarsine oxide (cacodylic acid). Herbicide Blue was formulated to contain cacodylic acid (as the free acid) and the sodium salt of cacodylic acid (sodium cacodylate). The percentages of the formulation were as follows:

cacodylic acid 4.7%
sodium cacodylate 26.4%
surfactant 3.4%
sodium chloride 5.5%
water 59.5%
antifoam agent 0.5%

The liquid formulation contained 15.4% of arsenic in the organic pentavalent form, a form of arsenic having low mammalian toxicity and rapidly “inactivated” by the clay and organic matter in the soil (Cullers et al.1976).

As previously noted, colored bands were painted around the centers of the 208-l drums in order to allow support personnel to readily identify the specific herbicide contained in the drums (Irish et al. 1969). Prior to March 1965, a 30-cm band was used. Subsequently, all herbicide drums were marked with a 7.6-cm color-coded band. Storage tanks were similarly color-coded by painting them for identification. Figure 2.5 shows the storing and labeling of Herbicide Orange for shipment to South Vietnam.

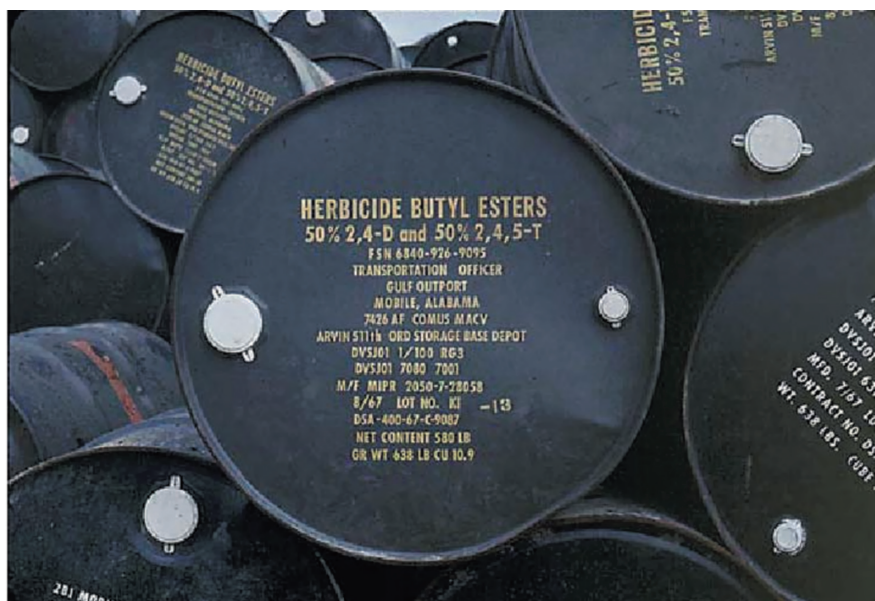


Fig. 2.5 A shipment of Herbicide Orange in 208-l drums. The lid (top) of each drum specified the content (Herbicide Butyl Esters of 2,4-D and 2,4,5-T), the Federal Specification Number (FSN), US Port of Embarkation (Mobile, Alabama), destination (ARVN 511th Ordinance Storage Depot, Da Nang, Vietnam), procurement information (including date, 8/67), and net weight. Each of the 11 different companies that manufactured military herbicides packed them in new 208-l 18 gauge steel drums for shipment to Southeast Asia. Each herbicide drum was also marked with a 7.6-cm color-coded band around the center to identify the specific military herbicide (Photograph courtesy of A. L. Young)

2.5 Physical Properties, Handling and Safety Evaluations of the Tactical Herbicides

In anticipation of the deployment of the tactical herbicides, Fort Detrick initiated tests on the physical properties of the normal butyl esters of 2,4-D, 2,4,5-T, and Orange Herbicide (Henson 1965). In the storage, transport, and dissemination of the tactical herbicides the knowledge of such properties as the temperature-viscosity correlation, specific heat, freezing point, surface temperature, thermal conductivity, and flow characteristics are important as to how the materials will be used (Henson 1965). The Physical Sciences Division of the Directorate of Biological Research conducted the study of Orange Herbicide for the above parameters in early 1965. The results indicated that Orange Herbicide would be compatible with the UC-123 RANCH HAND aircraft and both the MC-1 Hourglass, and the A/A45Y-1 Internal Defoliant Dispenser Systems as well as with the Helicopter HIDAL Spray System (Boyer and Brown 1964; Henson 1965; Scheidecker 1966). Similar evaluations were conducted for both White and Blue (Irish et al. 1969).

The toxicology of 2,4-D and 2,4,5-T have been determined and re-determined numerous times and extensively published beginning with evaluations in 1954 (Rowe and Hymas 1954). In 1967, the Plant Sciences Laboratories prepared a document on the toxicity of the herbicides in use in Vietnam (Minarik and Darrow 1967). At least three major comprehensive reviews have been conducted on the toxicology and human risks of the phenoxy herbicides (Young et al. 1978; Bovey 1980; Lavy 1987). Comprehensive reviews of the toxicology of cacodylic acid were published in 1965, 1967, and 1985 (Bailey and White 1965; Frost 1967; Hood 1985). A review of the public health implications of the widespread use of picloram was published in 1971 (Johnson 1971). A more comprehensive assessment of the health risks of herbicides in forestry, including picloram, 2,4-D and 2,4,5-T was conducted by Oregon State University (Walstad and Dost 1984). The literature studies conducted by the Midwest Research Institute on the safety and the ecological consequences of the repeated use of herbicides in South Vietnam concluded:

The possible toxic hazards involved in the aerial spraying of herbicides in Vietnam are of concern to scientists and to the public.... After examining the voluminous toxicity data and the actual rates at which these chemicals have been applied we can make the following observations: (1) the direct toxicity hazard to people and animals on the ground is nearly nonexistent, (2) destruction of wildlife food and wildlife habitat will probably affect wildlife survival more than any direct toxic effects of the herbicides, (3) the application of Orange or White alongside of rivers and canals or even the spraying of the water area itself at the levels used for defoliation is not likely to kill the fish in the water, (4) food produced from land treated with herbicides will not be poisonous or significantly altered in nutritional quality; if residues of a more persistent herbicide such as picloram should carry over to the next growing season it would retard plant growth rather than concentrate some toxic residues in the crop, (5) toxic residues of these herbicides (Orange, White, and Blue) will not accumulate in the fish and mean of animals to the point where man will be poisoned by them, and (6) the primary

ecological change is the destruction of vegetation and the resulting ecological succession in the replacement of this vegetation (House et al. 1967).

The Air Force Armament Laboratory at Eglin AFB, Florida, the Air Force Environmental Health Laboratory, at McClelland AFB, California; the Air Force Occupational and Environmental Health Laboratory, Kelly AFB, Texas; the Plant Sciences Laboratory at Fort Detrick; and, the United States Army Environmental Hygiene Agency, Aberdeen, Maryland, were responsible for determining physical properties, efficacy, toxicology, safe handling procedures, and actions to be taken for spills, environmental contamination, and disposal for all of the tactical herbicides (Young 2006).

The Air Force trained its aircrews for RANCH HAND operations including the handling of the tactical herbicides at Eglin AFB Auxiliary Field No. 9, Hurlburt Field (Cecil 1986). Frequently the training would involve actual spray missions at Eglin's Test Area C-52A, the fully instrumented test array established for the evaluation of the spray equipment by the Air Development Test Center and the Air Force Armament Laboratory (Buckingham 1982). The training of the Army Chemical Corps personnel to handle herbicides was the responsibility of the Army Chemical Corps Training Center at Fort Leonard Wood, Missouri (Irish et al. 1969; Young 2006).

2.6 The Procurement and Management of Tactical Herbicides

2.6.1 Purchase Descriptions for the Tactical Herbicides

In 1962, the responsibility for the management of tactical herbicides was assigned to the United States Air Force Logistics Command (AFLC), and specifically to the Middletown Air Materiel Area (MAAMA), Olmsted Air Force Base (AFB), Pennsylvania (SAAMA 1968). With the implementation of the "Operational Phase of Operation RANCH HAND" in August 1966, the management for tactical herbicides was transferred to the San Antonio Air Materiel Area (SAAMA), Kelly AFB, Texas (SAAMA 1968; Craig 1975). Management responsibilities included the procurement and shipment of all the tactical herbicides sent to Vietnam. Although the United States Army Chemical Corps, and specifically the Plant Sciences Laboratories at Fort Detrick, was responsible for the selection, evaluation, and purchase description of the herbicides, the Product Engineering Branch, Directorate of Aerospace Fuels, San Antonio Air Logistic Command at Kelly AFB was the organization that contracted for the tactical herbicides Orange, White and Blue through the Directorate of Procurement and Production, Defense General Supply Center, Defense Supply Agency, Richmond, Virginia (Irish et al. 1969; Craig 1975; Young 2006).

The Army Chemical Corps had responsibility for the purchase descriptions of the tactical herbicides. The chemical compositions of the tactical herbicides

were those that had been selected by the Army Chemical Corps through the years of testing and evaluation. The descriptions were classified as “Military Specifications” and were complete documents that were used when the need for the purchase of a material was confined to a specific military operation (e.g., the herbicides used in tactical operations in Vietnam). “Military Specifications” were noted by the lead identifier; for example:

- MIL-H-51148, Herbicide N-Butyl 2,4,5-Trichlorophenoxyacetate,
- MIL-H-51147, Herbicide N-Butyl 2,4-Dichlorophenoxyacetate.

Under the Purchase Description, additional documents would have included:

- MIL-STD-105, Sampling Procedures and Tables for Inspection of Attributes,
- MIL-I-45208, Inspection Systems Requirements [Department of the Air Force 1974].

In the case of Herbicide Orange as a finished mixture, the Military Specifications would have provided details on the composition (e.g., 50% by volume of MIL-H-51147, and 50% by volume of MIL-H-51148), tolerance range for the composition (e.g., the free acid could not exceed 0.5% by weight), the specific gravity of the composition (1.220–1.242 at 20°C), quality assurance provisions (e.g., Test Methods), and preparation for delivery (e.g., the placing of the orange band around the center of the drum) [Department of the Air Force 1974]. Because Herbicide Orange was a “Tactical Herbicide” purchased under Military Specifications, the contract with the Chemical Company that won the bid for a specific quantity of herbicide had the following note:

Precaution, IMPORTANT. For procurement of this herbicide for use on lands owned or otherwise managed as military installations, use Federal Specification 0-H-00200. Herbicides procured by this specification (i.e., Military Specifications) must not be diverted to domestic use.

The last purchases of Herbicide Orange procured by the Air Force were under Purchase Description AFPID 6840-1, dated 23 February 1968, and Amendment 1, dated 11 April 1969 (Department of the Air Force 1974). The Purchase Description AFPID 6840-1 contained all of the information noted above, plus the requirement for 18 gauge metal 55-gal (208-l) drums (Specification PPP-D-729) “for shipment of non-corrosive materials” (Department of the Air Force 1974).

The Defense Supply Agency (DSA) procured all tactical herbicides. DSA required the manufacturers to obtain the 55-gal (208-l) drums that met the required specifications and to arrange for all transportation (primarily by rail) of the drums from the chemical companies manufacturing plants to the Port of Embarkation (POE) (Craig 1975). The purchase contracts covered the costs of the herbicide, the drums, and the shipment. The chemical companies were selected on the basis of competitive bids and DSA provided the specifications

(those developed by the Army Chemical Corps and refined by the Air Force Logistic Command) required to be met by the manufacture (Craig 1975).

2.6.2 Quantities of Tactical Herbicides Procured

The procurement of the first tactical herbicides (Green and Pink) sent to Vietnam was at the direction of the Army Chemical Corps at Fort Detrick, and purchased by the Department of Army. All of Herbicide Green (n-butyl 2,4,5-T, 365 drums) and 365 drums of Herbicide Pink purchased directly from Dow Chemical Company, Midland, Michigan and airlifted on 13 November 1961 arriving in Saigon (Tan Son Nhut Airport) on 20 November 1961 (Brown 1962; Hanson 1965; Buckingham 1982). In addition, the Department of Army had also procured 15,000 pounds of Ansar 138® (cacodylic acid) from Ansul Chemical Company, Marinette, Wisconsin and this too was airlifted to Tan Son Nhut Airport arriving on 20 November 1961 (Buckingham 1982).

There is much confusion about the surplus herbicide that was manufactured in 1952 and used in aerial spray tests at Eglin AFB, Florida and Dugway Proving Ground in 1952–1953. A note in a letter exchanged between managers at Dow Chemical Company in 1965 stated:

November 1961: Bid DA-30-070-CML-1636 was for a total of 684,000 lbs. Dow had an inventory of 321,000 lbs of a blend of 75% Normal Butyl Ester of 2,4-D and 25% Normal Butyl Ester of 2,4,5-T which was war surplus, which we had repurchased. We added 160,500 lbs of iso-butyl of 2,45-T to make 481,500 lbs that was sold to the US Army Procurement at a negotiated price of \$0.4763 lb. The balance of 203,300 lbs was sold at \$ 0.6143 lb (Hanson 1965).

The above note identified the final product as “Purple” (Hanson 1965). As reported in Table 2.2, five companies produced Herbicide Purple and three companies produced Herbicide Pink. White was a proprietary product of Dow Chemical Company and Blue as Phytar 560 G was a product produced by Ansul Chemical Company, but in 1970, the Defense Supply Agency obtained 475 drums of Blue from Diamond Shamrock Company. The procurement records indicated that the Department of Army directly purchased Green, Pink and Purple through 1963. In 1964, the Defense Supply Agency had the responsibility.

The quantities of tactical herbicides in Table 2.2 exceeded the quantities of tactical herbicides reported in Table 1.1 because Table 2.2 includes the Herbicide Orange returned from Vietnam in Operation PACER IVY and the Herbicide Orange that remained in the United States and not shipped to South Vietnam after 1968 (Young et al. 2008). In addition quantities of Purple, Orange, White, and Blue were used in test programs at Eglin AFB, Florida and in test and evaluation programs conducted by the Army Chemical Corps, and in disposition studies conducted in the 1970s (see Table 5.7) (Young 2006).

Table 2.2 The quantities (208-l, or 55-gal, drums) of the six Tactical Herbicides, and the companies that supplied the herbicides from 1961 to 1971 [data obtained from DSA and AFLC Records, with the most recent procurement records obtain March 2008]

Company	Numbers of 208-l drums of each formulation					
	Orange	White	Blue	Purple	Pink	Green
Dow Chemical Company	78,235	105,700		2,840	180	365
Monsanto Company	67,065			7,320	520	
Hercules Inc.	49,945			1,095		
Thompson-Hayward Chemical Company	21,055				400 ¹	
Diamond Alkali /Shamrock Company	12,555		475	1,430	620	
US Rubber Company (Uniroyal, Inc)	11,635					
Thompson Chemicals Corporation	7,185				305 ¹	
Agrisect Company	1,875			95		
Hoffman-Taff, Inc.	410					
Ansul Chemical Company ²			29,655			
Total	249,960	105,700	30,130	12,780	2,025	365

¹This volume was 2,4,5-T remaining at termination of contracts in 1969; some of this 2,4,5-T may have been from Thompson and Thompson-Hayward.

²This is PHYTAR 560G, and does not include the 95 drums of ANSAR 138 shipped in 1961 to Vietnam.

2.6.3 Ports of Embarkation

In the contracts negotiated with the various chemical companies that produced the herbicides, a statement was included on where the tactical herbicides were required to be shipped, i.e., to the Port of Embarkation (POE). Prior to 1966, the Middletown Air Material Area (MAAMA), Olmsted AFB, Pennsylvania, had the responsibility for the procurement and management for the tactical herbicides (SAAMA 1968; Craig 1975). In the procurement contracts, MAAMA selected various Ports of Embarkation for shipping the tactical herbicides to South Vietnam. Ports at New Orleans, Baltimore and Seattle were frequently used by the Department of the Army and, subsequently (in 1963) by MAAMA (SAAMA 1968; Craig 1975). After 1966, all shipments of tactical herbicides to Vietnam were the responsibility of SAAMA and were shipped from the Port of Mobile, Mobile, Alabama, or the Outport at Gulfport, Mississippi (Craig 1975).

2.6.4 Management of the Tactical Herbicides

The management of the tactical herbicides was the responsibility of MAAMA (Olmsted AFB, Pennsylvania) until it transferred to SAAMA (Kelly AFB,

Texas) in August 1966. The procurement responsibility remained at the Defense General Supply Center at Richmond, Virginia. Research and Development responsibilities for new herbicides were assigned to the Army Chemical Corps at Fort Detrick, while the Air Force Armament Laboratory (AFATL) was assigned the research and development responsibility for equipment support testing (Craig 1975). Within SAAMA, the Directorate of Air Force Aerospace Fuels was assigned the “Program Management” for receiving, storing, shipping, providing transportation, inventory counting, and redistribution and marketing. User management responsibilities dictated a monthly inventory including: open inventory, receipts, disposition, usage, and closing inventory (Craig 1975). Requirements for tactical herbicides used in Southeast Asia were developed by the Army’s Chemical Operations Division (J-3), Military Assistance Command, Vietnam (MACV); passed to 7th Air Force of PACAF (Pacific Air Force Command) for coordination; to CINCPAC (Commander in Chief, Pacific Command) for review as required; and to the Joint Chief of Staff and Headquarters, United States Air Force for approval and budgetary processing. SAAMA related these requirements to the mission capability of RANCH HAND, after which the quantity to be procured was determined, the necessary budget allotment obtained, the procurement documents (Military Interdepartmental Procurement Request – MIPR) prepared, and after purchase, the products to be delivered to Vietnam (Craig 1975).

SAAMA based the supply support of tactical herbicides to Southeast Asia on a 180-day (six months) lead-time. This was computed as follows: 60-day supply in Vietnam that represented a 30-day supply at each of the two storage depots, the 20th ARVN (Army of the Republic of Vietnam) Ordnance Depot at Saigon, and the 511th ARVN Ordnance Depot, Da Nang Air Base; 30-day safety level in depot supply, 30 days to process the MIPRs, 15 days production time, and 45 days in the pipeline (i.e., acquisition through shipment) (Craig 1975). Of importance to the purchase and deliverance of the tactical herbicides to Vietnam was the following policy:

When the drums of tactical herbicides arrived in Vietnam, the ownership was transferred from the United States Air Force to the ARVN. The ARVN had the responsibility for the handling, transport, and storage of the tactical herbicides. In addition, ARVN Commanders, at each of the air bases where the tactical herbicides were shipped, had the responsibility for the final disposition of the empty drums. Thus, the ARVN directed where both full drums of tactical herbicides or the empty drums would be temporarily stored at the air bases where RANCH HAND aircraft were serviced. Most of the personnel involved in the actual handling of the drums of tactical herbicides were ARVN troops assigned to support the RANCH HAND operation (Young and Andrews 2006).

Drummed herbicides were shipped by rail from the manufacturer to the Port of Mobile in standard boxcars. Approximately 128 drums were loaded per boxcar. At the railroad terminal, the drums were loaded on pallets and taken to the pier by forklifts. The ship’s crane picked up the drums from the pallets and swung them aboard the ship where they were vertically stacked below deck, normally three high

for movement to Vietnam. The Port of Mobile was used because cost and time-wise it was the most economical (Craig 1975). From the Port of Mobile to the Port of Saigon, the time varied from 47 to 52 days (Craig 1975).

2.6.5 Summary of What Defined Tactical Herbicides

The Herbicides coded Purple, Pink, Green, Orange, Blue, and White were developed as “Tactical Herbicides”. The United States Army Chemical Corps’ Plant Science Laboratory at Fort Detrick, Maryland, was responsible for the screening, testing, and evaluating of tactical herbicide candidate formulations at numerous sites throughout the United States, Puerto Rico, Canada, and Thailand. The Plant Sciences Laboratories were also responsible for establishing the “Military Specifications” for those herbicides selected to be used as “Tactical Herbicides”. The ground and aerial spray equipment were developed by the both the Army Chemical Corps and the United States Air Force to support tactical combat military operations in Southeast Asia. The Department of Defense provided the training of aircrews, ground based personnel, and the Army Chemical Corps personnel that had responsibility for handling and spraying of the tactical herbicides. The selection and use of the tactical herbicides were exempt from USDA regulatory oversight, or from the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). In pesticide procurement catalogs the listing of a tactical herbicide was always accompanied by the statement: “This item is for tactical purposes only and not for base type pest control operations” (Adams 1970).

2.7 The Role of the Armed Forces Pest Control Board and Commercial Herbicides

On 17 November 1956, Department of Defense Directive 5154.12 established the Armed Forces Pest Control Board (AFPCB) {subsequently The Armed Forces Pest Management Board (AFPMB)} (AFPCB 1974). The purpose for establishing the AFPCB was to provide oversight of the DOD’s pest management programs on its more than 600 world wide military installations. At the time the Board was established, the Department was using million of pounds of commercial pesticides on these installations. The DOD Directive required that the Board be composed of members from the Army, Navy, Air Force and selected Defense Agencies (a total of 20 members). The Board was also to have 24 liaison members and 25 non-DOD Agency representatives. The Board established 8 Standing Committees: Environmental Impact, Equipment, Quarantine, Medical Entomology, Pesticides, Real Property Protection, Stored Products, and Training, Certification, and Manpower. In August 1961, the Department of Defense, via a

Memorandum of Understanding, established with the USDA a support program that among other responsibilities provided the research, recommendations, and specifications of pesticides that were suitable and met the need for DOD use (Fleck 1961; AFPCB 1974).

The Armed Forces Pest Control Board required all DOD agencies to use pesticide formulations that had “Federal Specifications”, with the labeling and use directions approved by the Pesticides Regulation Branch of USDA (now EPA), and in full compliance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) (Fleck 1961). As previously noted the “Tactical Herbicides” were required to meet “Military Specifications”. There were four distinct “types of specifications”. These were: (1) Purchase descriptions; (2) Army, Navy, and Air Force Specifications; (3) Military Specifications; and, (4) Federal Specifications. Purchase descriptions were merely descriptions of the material desired and are used for filling small needs or for materials that are needed on an emergency basis. They were issued by all government agencies and were of a temporary nature. Army, Navy, and Air Force Specification covered items specific to one of these military services (e.g., a biocide for ship hulls). Military Specifications were complete documents and were used when the need for the material was confined to a specific military operation (e.g., the herbicides Orange, White, and Blue used in tactical operations in Vietnam). The AFPCB adopted the policy for the Department of Defense to recommend that any pesticide formulation that had uses in civilian agencies be issued as a “Federal Specification”. These types of pesticide were to be issued by the General Services Administration (tactical herbicides were the responsibility of the Defense Supply Agency) (Fleck 1961).

By 1966, the AFPCB strictly controlled the kinds and forms of pesticides available under “Federal Specifications” and on the military supply list (Wickham 1968). New pesticides, before being considered by the Board, had to be recommended by the US Department of Agriculture, the Fish and Wildlife Service, or the Public Health Service, and the proposed use must have been approved by all three of these organizations (AFPCB 1974). In February 1967, the Federal Committee on Pest Control (FCPC) was established. All Federal pest control activities were placed within the purview of the Committee. The Committee was composed of two members from each of the Departments of Agriculture; Defense; Health; Education, and Welfare; and Interior. Before a pesticide was approved for use in the United States, or by a Federal Agency, it had to be reviewed by the FCPC (FCPC 1967). The DOD’s “Tactical Herbicides” were exempt from this approval and oversight process. However, all other herbicides used by the Department of Defense were required to meet this approval process. The significance of this action was that herbicides used in 1967–1970 on the more than 600 military installations managed by the Department of Defense required approval by both the AFPCB and the FCPC (after 1970, the registration and oversight of commercially available pesticides was the responsibility of EPA) (Hobson and Donnelly 1994). This requirement applied to all herbicides used in Vietnam that were NOT TACTICAL HERBICIDES.

Thus, herbicides used on Allied Bases in Vietnam around buildings, in equipment storage sites, and along interior roads came under the requirements of the AFPCB. The responsibility for the purchase and application of commercial pesticides on these installations was the Base Civil Engineer, NOT the Army Chemical Corps. The tactical herbicides were NOT approved for these uses. The insecticides used in Operation FLYSWATTER (the aerial application of insecticides to control mosquitoes in Vietnam) were under the Military's Disease Prevention Program and were approved by the AFPMB (Cecil and Young 2008).

With the establishment and functioning of the AFPCB, anytime that a DOD Military Base, e.g., Andersen AFB, Guam, or Osan AB, Korea, requested the use of a herbicide to control plant pests, the selection of the herbicide must have been approved by the Board (Kaufman 1968). Locally purchased pesticides were to be approved by the Command Entomologist. Moreover, the application of the herbicide had to be done by a Board "certified" (trained) applicator, and with equipment that had been approved by the USDA, and under the supervision of the Base Civil Engineer (Kaufman 1968; AFPCB 1977). The Department of Agriculture's Agricultural Research Service (ARS), and the Cooperative State Research Service (CSRS) provided critical support to the development of pesticides that were subsequently recommended and approved for use by the AFPCB (Shepard and Mahan 1965). The Board DID NOT work with the chemical companies that manufactured the pesticides, rather these materials were evaluated by ARS, the various State University Experiment Stations, and the State and Federal Extension Services. AFPCB even depended upon CSRS and its University-based research and extension system to prepare and publish manuals on pesticide use, plans for certification of pesticide applicators, and the disposal of old pesticides and pesticide containers (Shepard and Mahan 1965; Laudani 1967; WGP 1970). The final statements on safety and environment precautions on the use of herbicides that would be commercially available to the military were determined by the agencies of the Public Health Service, and when necessary by the United States Army Environmental Hygiene Agency (Brown 1961; USAEHA 1987).

To ensure that military installations were identifying and controlling pests that were detrimental to military personnel, property, projects, and programs, the AFPCB had a cadre of military and civilian personnel via supporting Agencies and Laboratories (e.g., the Epidemiology Division of the School of Aerospace, Brooks AFB, Texas; USAF Occupational and Environmental Health Laboratory, Kelly AFB, Texas; USAF Environmental Health Laboratory, and the United States Public Health Service) that routinely conducted Pest Surveys, Staff Visits, Training Programs, and Conferences on identifying and controlling pests. Reports of these visits, programs, and conferences were published by the Board and widely circulated to other military installations (Brown 1961; Kaufman 1968; McNeal 1969; NAVFAC 1984).

2.7.1 Summary of the Use of Commercial Herbicides by the DOD

Under the Directives 5154.12 and 4150.7, the Department of Defense gave the Armed Forces Pest Control Board/Armed Forces Pest Management Board the authority to set pest management policy “applicable for all Department of Defense pest management activities in any unit, at any time, in any place, even when conducted by contract operations.” The significance of this Directive is that any herbicides used after 1961 on DOD’s more than 600 installations must have been approved by the Board, and must have met USDA’s regulatory requirements, and all the requirements of FIFRA. The exception to these Directives was the development of the “Tactical Herbicides” sprayed in combat military operations in Vietnam, or by Department of State approval as used in Korea adjacent to the Demilitarized Zone in 1968 (Young 2006).

2.8 Implications of Tactical Versus Commercial Herbicides

Herbicides used in Operation RANCH HAND for defoliation and crop destruction projects, and by the US Army Chemical Corps for vegetation control on perimeters, cache sites, and similar militarily-important targets were classified as “Tactical Herbicides” and were formulated, tested, evaluated, and assigned “Military Specifications” by the Department of Defense. They were not subject to regulatory oversight by the Department of Agriculture, the Armed Force Pest Control Board, or the Federal Committee on Pest Control. However, the insecticides used in Operation Flyswatter were subject to the AFPCB, as were all other pesticides used for control of pests within the boundaries of the military installations in Vietnam.

There were no documents that indicated the herbicides used in Guam, or CONUS military installations were “tactical herbicides”, rather, the available documents confirmed that all pesticides used in these locations and other US Department of Defense installations world wide were those commercially available and approved by AFPCB.

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