

EXHIBIT

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PROJECT AGILE PROGRAM COMPLETION REPORT

Program Title: Defoliation Research

Program Element: 62702E

ARPA Order Nos.: 256
423
424
481
572
1086

DARPA Agents: US Army Biological Laboratories
USAF Systems Command (Det. 4, RTD/DAD)
US Department of Agriculture

Report Preparation Date: January, 1981

0312210

EXECUTIVE SUMMARY

Military interest in the potential of herbicides began in 1942 when recommendations by the War Research Service, a civilian agency established by Secretary of War Stimson, noted their potential as anti-crop/defoliant agents and recommended further investigation. The phenoxyacetic acids (which include 2,4-D and 2,4,5-T - the chemicals used in AGENT ORANGE) were first synthesized by Zimmerman and Hitchcock of the Boyce-Thompson Institute in 1942 and immediately attracted much interest due to their phenomenal effectiveness in comparison with the then standard herbicides. The US Army funded a number of research efforts on the phenoxyacetic acid compounds as part of their assigned mission at the newly established Camp Detrick. Although the overall effort was classified until the end of WWII, by 1945 sufficient unclassified reporting had occurred to interest a number of chemical companies in the production and commercial marketing of 2,4-D. The first of these commercial products, introduced in 1945, was "WEEDONE" which is still sold today in garden and hardware stores across the US.

While US commercial and agricultural use of herbicides burgeoned from a \$1 million/year to a \$200 million/year industry during the period 1945-1961 military research during this period was carried out at a low level with Camp Detrick screening new chemicals at the greenhouse and small plot level. One major aerial test was conducted at the Camp Drum, NY artillery range in 1959 during which a four square mile area was defoliated with a mixture of 2,4-D and 2,4,5-T (AGENT PURPLE) which had been obtained from the US Department of Agriculture at Beltsville, MD.

Understanding of any RDT&E effort must be undertaken within the context of the specific times involved and the overall aims and expectations of the US Government at that particular point in history. In April 1961 the US had just had the experience of the Bay of Pigs as evidence of the difficulties involved in countering insurgency. As a direct result of this experience President Kennedy established the Special Group for Counter-Insurgency under the chairmanship of General Maxwell D. Taylor, the Military Representative of the President, and assigned them the immediate task of aiding the Republic of Vietnam in their CI effort. At the beginning of 1961 there were 685 US military advisors in Vietnam. By the end of 1962 there were 10,000. The initiation of ARPA's research on the military use of herbicides took place during this period of intense pressure to increase US support of the Republic of Vietnam's counterinsurgency effort.

In June 1961, responding to a direct request from President Ngo Dinh Diem of the Republic of Vietnam, (concurrent in and forwarded by the US MAAG in Vietnam and approved by the Secretary of Defense and the DDR&E) ARPA initiated a crash task to deploy spray equipment and commercially available herbicides to Vietnam to evaluate the feasibility of defoliating tropical vegetation. The state-of-the-art with respect to aerial spray equipment suitable for military aircraft was essentially non-existent since the only hardware available in the DoD inventory was designed for the application of less viscous insecticides at

a much lower application rate. Commercial aerial spray rigs used for powerlines and rangeland were configured for crop-dusting aircraft and were in the main of small capacity and low reliability. The favored commercial herbicides were formulations of 2,4-D and 2,4,5-T plus the desiccant cacodylic acid. Although the tests conducted in the fall of 1961 were plagued with problems the feasibility of defoliating tropical vegetation was demonstrated. It is worth noting at this point that other parts of DoD and the Department of State initiated the operational deployment of USAF spray equipped aircraft and AGENT PURPLE in September 1961, some six weeks after the first feasibility test spraying in Vietnam and long before any data on effectiveness, persistence, required dosage levels or deposition techniques had been established.

In response to the May 1962 recommendations of a DDR&E directed evaluation team ARPA carried out over the next five years a number of specific research tasks at a total cost of \$3.2 million. These efforts were aimed at the two major deficiencies in the state-of-the-art: inadequate aerial spray hardware and inadequate data on required spray deposition rate, foliage response and persistence of defoliation. In the main these efforts achieved their goals and were useful to the concerned operational commands in the later stages of the Vietnam experience.

No Project Completion Summary on defoliation would be complete without the following quotes from a 2 April 1962 memorandum from DDR&E Harold Brown to Secretary of Defense Robert S. McNamara. Subject: Defoliant Experimentation and Operational Tests.

"I feel it would serve no useful purpose to look further for evidence of 'who said what to whom.' It is apparent that the momentum of the exercise, strongly backed as it was by GVN, U.S. Embassy, MAAG, Taylor Mission, DOD, including DDR&E, and White House pressures, and the directives issued from JCS through CINCPAC, were sufficient to carry forward the first operational mission in January."

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"This experience has illustrated rather clearly, I believe, the necessity for maintaining the integrity and independence of RDT&E activities against the pressures of immediate operational requirements until individual systems are fully certified for operational use on a technical basis. While the record clearly shows that defoliants were conceived as one of several concurrent measures which, taken together, might assist in altering the course of the guerrilla struggle, such warnings and qualifications were too easily forgotten on all sides of the house (including mine) in the search for a 'single solution' as a means to win the war."

It was to be three and a half years before the results of the ARPA sponsored research in Thailand were available to the US Military Command in Vietnam. During this period some 1,000,000 gallons of herbicidal agents were sprayed operationally.

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E - Thailand Defoliation Test Program

F - USDA Defoliation Studies

G - Ecological Effects of Herbicides

Section IV - Consolidated Bibliography

1961 1962 1963 1964 1965 1966 1967 1968 1969

----- RVN Feasibility Study

----- Spray Systems Mod & Test

----- Herbicidal Bomblet Clusters

----- A/A 45Y-2 Spray System

----- AO 423 (Thailand)

----- AO 424 (USDA)

--- Ecology Effects

FUNDING SUMMARY

(S000's)

AO	LINE	AGENT	FY61	FY62	FY63	FY64	FY65	FY66	FY67	FY68	TOTAL
--	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
256	G926111	BIOLABS	90	324	148	32	0	0	0	0	594
	G926112										
	G926113										
	G926114										
	G926116										
423	G911722	BIOLABS	0	0	697	0	0	0	0	0	697
424	G911721	USDA	0	0	720	0	300	300	0	0	1320
481	G926115	AFSC	0	0	401	0	0	0	0	0	401
256	G926117A	CRDL	0	31	0	0	0	0	0	0	31
572	G926117B	CRDL	0	0	0	85	0	0	0	0	85
1086	NONE	DSSW	0	0	0	0	0	0	0	62	62
	TOTALS		90	355	1966	117	300	300	0	62	3190

PROGRAM TITLE

RVN Feasibility Studies

ARPA ORDER 256

FUNDING - \$50 K

Basic (FY61) - \$15,000
Amd 1 (FY62) - \$17,500
Amd 3 (FY62) - \$17,000

PERFORMANCE PERIOD

June 1961 thru May 1962

ARPA PROGRAM MANAGERS

William J. Lynch Jun 61 to May 62

AGENT

US Army Biological Laboratories (USABIOLABS)

CONTRACTOR

USABIOLABS - Crops Division

KEY CONTRACTOR PERSONNEL (Data valid 1962)

Dr. James W. Brown (Feasibility Team Leader)
Crops Division
US Army Biological Laboratories
Fort Detrick
Frederick, MD 21701

Fred J. Delmore, Brigadier General (Evaluation Team Leader)
Commanding General
US Army Chemical Corps Research and Development Command
Edgewood Arsenal, MD 21010

OBJECTIVE

Using immediately available chemicals and spray equipment demonstrate the feasibility of defoliating or killing vegetation in Vietnam.

APPROACH

ARPA Research Phase (Jul 61 to Jan 62)

In response to an urgent request from the highest level of the Republic of Vietnam (RVN) government, relayed by the US Military Assistance Command, ARPA initiated a crash program to deploy commercially available chemicals and US Army Biological Laboratories (USABIOLABS) technical personnel to RVN to investigate feasibility.

The original approach called for the Republic of Vietnam Armed Forces (RVNAF) to apply the materials utilizing their aircraft and personnel and the ARPA tests were carried out in this manner.

The spray equipment consisted of:

- a) A USAF designed insecticide spray system mounted on a Vietnamese C-47 aircraft.
- b) Two externally mounted 148 spray tanks mounted on a Vietnamese AD6 aircraft.
- c) A USN designed insecticide spray system mounted on a Vietnamese H-34 helicopter.

The chemicals employed were:

- a) One formulation of 2,4-D (Conc 48)
- b) Two formulations of 2,4-D and 2,4,5-T (Dinoxol and PURPLE)
- c) Three formulations of 2,4,5-T (PINK, GREEN and Trinoxol)
- d) One formulation of cacodylic acid (BLUE)

USAF Operational Test Phase (Jan 62 - Mar 62)

Responding to direction from the Departments of State and Defense, issued to the Ambassador and the Chief, MAAG in September 1961, limited quantities of PURPLE and USAF spray equipped aircraft were requested thru operational channels. The first three USAF (RANCH HAND) C-123 aircraft arrived in-country in January 1962. These aircraft were equipped with MC-1 (Hourglass) spray systems configured for insecticide dispersal.

Evaluation Phase (Apr 62)

By February 1962 it had become apparent that pressures from many levels of both the US and RVN governments to "win the war" were far outpacing the generally subjective observations of the results of both the research and operational spray tests. Accordingly the DDR&E directed the formation of a high level interagency evaluation team consisting of representatives from the US Army, the US Department of Agriculture and the California State Department of Forestry under the direction of Brigadier General Fred J. Delmore, Commanding General, US Army Chemical R&D Command. The team was charged with carrying out, in Vietnam, a thorough evaluation of all spray test results to date and were further

directed to make specific recommendations for future operational use and further R&D needs.

RESEARCH RESULTS

ARPA Research Phase (Jul 61 to Jan 62)

A total of 19 tests, principally with the VN C-47, were carried out between July 1961 and January 1962 with mixed results. While no question remained that tropical vegetation could be defoliated and/or killed the inadequacies and unknowns for both the chemical formulations and the spray equipment were vividly obvious.

USAF Operational Test Phase (Jan 62 - Mar 62)

A total of 7 tests utilizing the C-123/MC-1 equipment were carried out in January 1962 with mixed results. Again the feasibility of defoliation was clear but the inadequacies and unknowns for spray equipment and chemical formulations remained.

Evaluation Phase (Apr 62)

The interagency team carried out detailed evaluations during April 1962 and concluded that:

Herbicides can unquestionably be used to control vegetation and the operational program should be continued provided that modifications in techniques and equipment are made.

One of the most important limiting factors is dispersal equipment and both quick-fix and longer term modification and R&D should be initiated.

Data on specific plant species reaction, seasonal variation and persistence of defoliation must be obtained and used in operational planning.

The specific R&D recommendations in the report formed the basis for all of ARPA's subsequent efforts.

OPERATIONAL UTILITY

While no hard data on the true operational value of the increased visibility occasioned by defoliation can ever be had the perceived utility can be seen from the following:

0312281

Military Herbicide

Est. gallons sprayed in RVN
(Jan 62 - Feb 71)

GREEN	(2,4,5-T)	8,208
PINK	(2,4,5-T)	122,792
PURPLE	(2,4-D & 2,4,5-T)	145,000
BLUE	(Cacodylic acid)	1,196,746
WHITE	(Picloram & 2,4-D)	5,632,904
ORANGE	(2,4-D & 2,4,5-T)	10,645,904

		17,751,554

REPORTS

AD 476 961

VEGETATIONAL SPRAY TESTS IN SOUTH VIETNAM

by J.W. Brown. Apr 62. 119p. Unnumbered Report, US Army Biological Laboratories

Unclassified / Limited

AD 368 997

VEGETATIONAL SPRAY TESTS IN SOUTH VIETNAM, SUPPLEMENT

by J.W. Brown. Apr 62. 136p. Unnumbered Report, US Army Biological Laboratories

Unclassified / Limited

AD A950097

REVIEW AND EVALUATION OF ARPA/OSD "DEFOLIATION" PROGRAM

by Fred J. Delmore, Warren C. Shaw, Levi T. Burcham, Charles E. Minarik, Donald Whittam. May 62. 96p. Unnumbered Report, US Army Chemical Corps Research and Development Command

Unclassified / Unlimited

ARCHIVE LOCATION

Accession No. 68-A-2576 , Box 1
Folder(s)
Defoliation Feasibility Team Reports

Accession No. 330-77-18 , Box 3
Folder(s)
Order No. 256 - Material for AGILE

PROGRAM TITLE

Spray Systems Modification and Test

ARPA ORDER 256

FUNDING - \$545 K

Amd 4 (FY61)	\$ 75,000
Amd 6 (FY62)	\$262,000
Amd 8 (FY62)	\$ 45,000
Amd 11 (FY63)	\$131,000
Amd 14 (FY64)	\$45,000
Amd 15 (FY64)	(-\$13,215)

PERFORMANCE PERIOD

June 1962 thru June 1964

ARPA PROGRAM MANAGERS

Ralph L. Clary	May 62 to Oct 62
Robert L. Burns	Oct 62 to Feb 64
Fred I. Edwards	Feb 64 to Jun 64

AGENT

U.S. Army Biological Laboratories

CONTRACTOR

U.S. Army Biological Laboratories
(U.S. Dept. of Agriculture)
(U.S. Air Force - Armament Test Laboratory)

KEY CONTRACTOR PERSONNEL (Data valid 1964)

Mr. Lester W. Boyer
Crops Division
U.S. Army Biological Laboratories
Fort Detrick
Frederick, MD 21701

OBJECTIVE

Carry out quick-fix and mid-range modifications to improve the performance of USAF and RVNAF spray systems in operational use in Vietnam. Conduct detailed aerial spray grid testing in the US to establish dependable dispersal data.

APPROACH

The first herbicidal spray systems employed in Vietnam were designed for use with liquid insecticides and were untested and marginally suitable for use with the more viscous herbicide formulations.

Based on the recommendations of the Delmore Defoliation Evaluation Group ARPA initiated a series of quick reaction modifications for the C-123/MC-1 (Hourglass) spray system and the H-34/HIDAL (Helicopter Insecticide Dispersal Apparatus-Liquid) spray system as well as interim and detailed spray grid calibration and testing of each system. During the course of the research a third spray system, the A1-H/FIDAL (Fixed Wing Insecticide Dispersal Apparatus-Liquid) was added.

The work was carried out jointly by U.S. Army Chemical Corps, USAF and U.S. Department of Agriculture personnel working under the overall direction of the Crops Division, U.S. Army Biological Laboratories.

RESEARCH RESULTS

C-123/MC-1 Spray System

Phase I (Jun-Sep 62)

Engineering modifications were made to the piping, wing booms, nozzles and valves to upgrade the dispersal rate to 1.5 gallons/acre from the initial rate of 1.0 gallon/acre.

Limited spray grid testing was carried out to determine optimum nozzle configuration and "best estimate" spray deposition patterns.

Three quick-fix kits were fabricated and sent to Vietnam with TDY technicians who assisted in the modification of the operational RANCH HAND aircraft.

Phase II (Sep 62-Jun 64)

Additional engineering modifications involving a high capacity dual pump system and an added tail boom were made and tested to demonstrate a 3.0 gallon/acre spray rate and a 300 micron MMD spray droplet size.

Detailed spray grid measurements were carried out and optimized aircraft speeds, altitudes and flow rates were established.

H-34/HIDAL Spray System

Phase I (Jun-Sep 62)

Engineering modifications were made to the spray nozzles and electrical wiring to improve the spray rate and mean time before pump failure.

Limited spray grid testing was carried out to determine optimum nozzle configuration and "best estimate" spray deposition patterns.

Quick-fix kits were fabricated and sent to Vietnam with a TDY technician who assisted in the modification of the operational RVNAF aircraft.

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Phase II (Sep 62-Jun 64)

Additional engineering modifications involving a more reliable pump motor/electrical system were made and five new modification kits were sent to Vietnam for installation.

Detailed spray grid measurements were carried out and optimized aircraft speeds, altitudes and flow rates were established.

A1-H/FIDAL Spray System

Procurement of six units, based on an insecticide dispersal concept, was initiated in November 1962 and units were delivered to Eglin AFB in February 1963. Multiple component failures developed during the next 15 months of testing and a number of modifications had to be made to bring the system to acceptable performance levels.

Detailed spray grid measurements were carried out and optimized aircraft speeds, altitudes and flow rates were established.

OPERATIONAL UTILITY

C-123/MC-1 Spray System

The quick-fix modifications (Phase I) and the more complex mid-term modifications (Phase II) were used operationally in Vietnam until the introduction of the USAF A/A45Y-1 spray system in 1965. The ARPA sponsored research made a major contribution to a more efficient and safer operational capability during that period.

H-34/HIDAL Spray System

Both the quick-fix and mid-term modifications were deployed to Vietnam and were installed on the operational RVNAF aircraft. However the level of RVNAF maintainance and pilot reluctance to fly missions may well have resulted in minimal operational utility.

A1-H/FIDAL Spray System

The ARPA R&D Field Unit in Vietnam was informed in November 1964 that an acceptable fixed wing herbicidal spray system now existed and was being further developed in an 80 gallon version by the U.S. Army and in a 135 gallon version by USAF. They were also informed that suitable tanks existed which could be adapted to meet the MACV specified 285 gallon version but that such adaptation should be levied on one of the Services. Although the ARPA Field Unit had for over a year been stating that MACV wanted such a system nothing in the record indicates that MACV ever levied a requirement on the Services or that any version of the FIDAL concept was ever deployed to Vietnam.

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REPORTS

AD 478 189

MODIFICATION AND CALIBRATION OF DEFOLIATION EQUIPMENT (C-123 - FIRST MODIFICATION)

by James W. Brown. JULY 1962. 102p. Unnumbered Report, U.S. Army Biological Laboratories

Unclassified / Unlimited

AD 478 190

SUPPLEMENT TO MODIFICATION AND CALIBRATION OF DEFOLIATION EQUIPMENT (C-123 - FIRST MODIFICATION)

by James W. Brown. JULY 1962. 44p. Unnumbered Report, U.S. Army Biological Laboratories

Unclassified / Unlimited

AD 478 158

SPRAY TEST CALIBRATION OF THE HIDAL (HUS-1 or H-34)

by James W. Brown. JULY 1962. 76p. Unnumbered Report, U.S. Army Biological Laboratories

Unclassified / Limited

AD 442 477

CALIBRATION OF SPRAY SYSTEMS

C-123/MC-1

H-34/HIDAL

A-1H/FIDAL

by Lester W. Boyer and James W. Brown. June 64. 110p. Report no. TR 46, U.S. Army Biological Laboratories

Unclassified / Unlimited

AD 478 189

AD 442 478

BASIC DATA
FROM C-123/MC-1 CALIBRATION TRIALS
1963

by Lester W. Boyer and James W. Brown. June 64. 354p. Report no.
TR 46-Supplement I, U.S. Army Biological Laboratories

Unclassified / Limited

AD 442 479

BASIC DATA
FROM H-34/HIDAL CALIBRATION TRIALS
1963

by Lester W. Boyer and James W. Brown. June 64. 306p. Report no.
TR 46-Supplement II, U.S. Army Biological Laboratories

Unclassified / Limited

AD 442 480

THE A1-H/FIDAL CONCEPT

by Lester W. Boyer and James W. Brown. June 64. 440p. Report no.
TR 46-Supplement III, U.S. Army Biological Laboratories

Unclassified / Limited

ARCHIVE LOCATION

Accession No. 68-A-2576 , Box 1

Folder(s)

Defoliation - FIDAL

Defoliation - MC-1/C-123

Defoliation - HIDAL

Spray Calibration Report - 1964 - MC-1,HIDAL,FIDAL

Accession No. 330-77-18 , Box 3

Folder(s)

Order No. 256 - Material for AGILE

PROGRAM TITLE

Herbicide Bomblet Clusters

ARPA ORDER 256

ARPA ORDER 572

FUNDING - \$116 K

AO 256

Amd 8 (FY62) - \$47,000

Amd 18 (FY62) - (-\$15,893)

AO 572

Basic (FY64) - \$100,750

Amd 2 (FY64) - (-\$15,325)

PERFORMANCE PERIOD

November 1962 thru March 1966

ARPA PROGRAM MANAGERS

Robert L. Burns Oct 62 to Feb 64

Fred I. Edwards Feb 64 to Mar 66

AGENT

U.S. Army CBR Agency, Edgewood Arsenal

CONTRACTOR

U.S. Army Biological Laboratories

KEY CONTRACTOR PERSONNEL (Data valid 1966)

Mr. Kent R. Irish

Program Coordination Office

U.S. Army Biological Laboratories

Fort Detrick

Frederick, MD 21701

OBJECTIVE

Evaluate/procure bomblet clusters for herbicide application to 'small plot' targets

APPROACH

In response to an urgent request from Military Assistance Command-Vietnam (MACV) a program was initiated in November 1962 to evaluate the Army's recently developed 'liquid agent' bomblet cluster assemblies for potential use with herbicides.

On the basis of preliminary test results made available in September 1963 MACV requested that ARPA procure specific quantities and ship to RVN for test soonest.

Procurement of test quantities was initiated in May 1964 and the items were available for shipment in October 1964.

In November 1964 MACV notified ARPA that there was no longer an interest in testing the items in RVN.

In January 1965 ARPA gave up its reclama and transferred the items to Fort Detrick for their use or disposal.

RESEARCH RESULTS

Two bomblet clusters were test dropped and evaluated in the US during 1963:

E-155 - 40 pound cluster containing 7 one-quart E-138 bomblets

E-156 - 150 pound cluster containing 28 one-quart E-138 bomblets

The evaluation report indicated that ground coverage from the clusters was adequate but not uniform and that the clusters would be a high-cost, special application only munition for extremely difficult targets.

OPERATIONAL UTILITY

None since the items were not deployed. The effort suffered from changing field requirements during a period when U.S. policy was changing radically.

REPORTS

AD 350 588

DESIGN & EVALUATION OF AN INTERIM ANTICROP WEAPONS SYSTEM

by Carl R. Thayer. May 64. 81p. Report no. TR 47, U.S. Army Biological Laboratories

Confidential (Release should be made by Dugway PG)

CONFIDENTIAL

ARCHIVE LOCATION

Accession No. 69-A-2242 , Box 3
Folder(s)
Defoliation - Crops/Bomblets

Accession No. 330-77-18 , Box 3
Folder(s)
Order No. 256 - Material for AGILE

Accession No. 71-A-1606 , Box 3
Folder(s)
Order No. 572 - Ballistic Bomblets & Clusters

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PROGRAM TITLE

A/A 45Y-2 Internal Defoliant Dispenser System

ARPA ORDER 481

FUNDING - \$401 K

Basic (FY63) - \$403,000
Amd 1 (FY63) - (-\$3,292.10)
Amd 2 (FY63) - \$1,344.25

PERFORMANCE PERIOD

June 1963 thru September 1964

ARPA PROGRAM MANAGERS

Robert L. Burns Apr 63 to Sep 63
Fred I. Edwards Sep 63 to Apr 65

AGENT

AFSC - Detachment 4, Directorate of Armament Development, Research and Technology Division, Eglin AFB

CONTRACTOR

Fairchild Stratos Corporation - Contract No. AF 08(635)3782

KEY AGENT PERSONNEL (Data valid 1965)

**Capt. Charles L. Flynn, USAF (Project Leader)
Detachment 4, Directorate of Armament Development
Research and Technology Division (AFSC)
United States Air Force
Eglin Air Force Base, FL 32542**

KEY CONTRACTOR PERSONNEL (Data valid 1965)

**Mr. Harry F. Andrew - (Project Engineer)
Aircraft - Missiles Division
Fairchild Stratos Corporation
Showalter Road and U.S. Route 11
Hagerstown, MD 21740**

OBJECTIVE

Demonstrate the feasibility of prepressurized defoliant dispenser systems.

APPROACH

In early 1963 USAF conducted an RFP exercise for new defoliant spray systems which resulted in a "winning" proposal from Hayes International for a pump-driven 1000 gallon system for C-123/C-130 aircraft. A "runner-up" proposal from Fairchild Stratos Corporation for an advanced concept development of an internally pressurized (high pressure gas bottles vice pump) modular 500 gallon system was forwarded to ARPA for funding consideration. AFSC stated their willingness to fund an extensive test program if ARPA would fund the system procurement contract. ARPA approved and funded the procurement of six modular units.

RESEARCH RESULTS

The contractor seriously underestimated the complexity of the task and suffered numerous delays and cost problems. The six modules were delivered to Eglin AFB in April-May 1964 rather than January 1964.

Extensive aerial testing of the system was carried out by Detachment 4, RTD during the period 23 April - 31 August 1964 utilizing a C-123 test-bed aircraft.

AFSC considered the delivered hardware to have met the contract specifications even though the system exhibited several engineering deficiencies which had to be corrected on site. However the modules were judged to be incapable of delivering 3.0 gallons per acre over a one half square mile area in one flight (a USAF minimum requirement).

AFSC stated that:

The feasibility of the prepressurized concept had been demonstrated.

A redesign of the system would be necessary to bring it to minimum operational performance levels.

No AFSC funds were available for the redesign but in-house effort would continue pending ARPA decision on further funding.

OPERATIONAL UTILITY

ARPA declined to provide redesign funding and transferred the hardware to AFSC (Detachment 4/RTD) for any in-house effort they desired.

No further USAF results or usage were ever reported. Coincidentally the AFSC funded Hayes International (A/A 45Y-1) system became the end operational system used in Vietnam.

REPORTS

AD 453 073

TEST AND EVALUATION OF THE A/A 45Y-2 PRESSURIZED DEFOLIANT DISPENSER

by Charles L. Flynn, Capt, USAF. Oct 64. 111p. Report no.
APGC-TR-64-72, Air Proving Ground Center, AFSC

Unclassified / Limited

AD 452 997

TEST AND EVALUATION OF THE A/A 45Y-2 PRESSURIZED DEFOLIANT DISPENSER
Supplement I - Tabulated Data

by Charles L. Flynn, Capt, USAF. Oct 64. 100p. Report no.
APGC-TR-64-72 (Suppl I), Air Proving Ground Center, AFSC

Unclassified / Limited

ARCHIVE LOCATION

Accession No. 68-A-2576 , Box 1
Folder(s)
Defoliation - FS/C-130

Accession No. 71-A-1806 , Box 2
Folder(s)
Order No. 481 - Defoliation Spray System

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PROGRAM TITLE

Thailand Defoliation Test Program

ARPA ORDER 423

FUNDING - \$697 K

Basic (FY63) - \$1,000,000
Amd 2 (FY63) - (-\$240,000)
Amd 3 (FY63) - (-\$ 63,155)

PERFORMANCE PERIOD

April 1963 thru June 1966

ARPA PROGRAM MANAGERS

Robert J. Heaston Dec 62 to Feb 64
Fred I. Edwards Feb 64 to Dec 67

AGENT

U.S. Army Biological Laboratories (USABIOLABS)

CONTRACTOR

USABIOLABS - Crops Division

KEY CONTRACTOR PERSONNEL (Data valid 1967)

Dr. Robert A. Darrow (Project Leader)
Crops Division
U.S. Army Biological Laboratories
Fort Detrick
Frederick, MD 21701

Dr. George B. Truchelet (Deputy Project Leader)
Crops Division
U.S. Army Biological Laboratories
Fort Detrick
Frederick, MD 21701

OBJECTIVE

Determine the effectiveness of aerial applications of various herbicides in defoliating tropical dry evergreen forest, secondary forest and shrub vegetation.

U.S. ARMY

APPROACH

Utilizing rigidly controlled conditions carry out a series of aerial spray tests on carefully defined test plots at the Royal Thai Army reservation at Pranburi, Thailand to:

Determine minimal rates and volumes of various mixtures of 2,4-D and 2,4,5-T applied at different seasons of the year for effective defoliation and control of representative vegetation of Southeast Asia.

Evaluate the effectiveness of other selected defoliant, dessicants, and herbicides applied singly or in combination mixtures at different seasons of the year on representative vegetation of Southeast Asia.

RESEARCH RESULTS

The research report was a model of conciseness and provided the first scientifically based series of operational parameters relating season and spray rate to speed and persistence of defoliation.

The publication of a single page table showing these relationships made available to operational personnel a ready reference for both planning and carrying out missions.

Specific finding of special interest were:

The defoliation responses to aerial applications of herbicides were influenced more by rate than by volume of spray solutions applied. Applications of 1.0-1.5 gallons per acre as pure chemical gave similar defoliation responses to the same amounts of chemical diluted with one or more volumes of diesel oil.

Optimum droplet sizes for rapid fallout and canopy penetration were in the range of 275 to 350 microns MMD.

Visual estimates and measurements of canopy obscuration from vertical photographs gave closely comparable evaluations of defoliation effectiveness. Horizontal measurements gave lower values than visual estimates or canopy obscuration measurements.

OPERATIONAL UTILITY

The provision of concise data cross relating spray rate, season and herbicidal effect permitted more accurate operational planning and application in Vietnam.

REPORTS

AD 486 540

OCONUS DEFOLIATION TEST PROGRAM

by Robert A. Darrow, George B. Truchelet, Charles M. Bartlett. Jul 66, 149p. Report no. TR 79, U.S. Army Biological Center

Unclassified / Limited

ARCHIVE LOCATION

Accession No. 69-A-2827 , Box 1

Folder(s)

Defoliation - Thai Tests - AO 423 - Policy - Reports

Defoliation - Thai Tests - AO 423 - Correspondance

Accession No. 71-A-1606 , Box 1

Folder(s)

Order No. 423 - Chemical Control of Vegetation

PROGRAM TITLE

Control & Defoliation of Tropical and Subtropical Vegetation

ARPA ORDER 424

FUNDING - \$1,320 K

Basic (FY63) - \$720,000

Amd 2 (FY65) - \$300,000

Amd 3 (FY66) - \$300,000

PERFORMANCE PERIOD

April 1963 thru June 1967

ARPA PROGRAM MANAGERS

Robert J. Heaston Dec 62 to Feb 64

Fred I. Edwards Feb 64 to Dec 64

Levi T. Burcham Dec 64 to Jul 66

Verne C. Fryklund Jul 66 to Jun 67

AGENT

U.S. Dept of Agriculture (USDA)

CONTRACTOR

USDA - Agricultural Research Service - Crops Research Division

KEY CONTRACTOR PERSONNEL (Data valid 1967)

Dr. William B. Ennis, Jr (Project Leader)

Chief, Crops Protection Research Branch

Crops Research Division

Agricultural Research Service

U.S. Department of Agriculture

Beltsville, MD 20705

Dr. Fred H. Tschirley (Deputy Project Leader)

Crops Research Division

Agricultural Research Service

U.S. Department of Agriculture

Beltsville, MD 20705

OBJECTIVE

To provide a better understanding of the technology of chemical control of vegetation.

APPROACH

Utilizing research teams combining the disciplines of weed science, taxonomy, and agricultural engineering located at research sites in Puerto Rico and Texas investigate the following:

- Evaluate new herbicides or combinations of herbicides for killing tropical and subtropical vegetation

- Determine the effects of environment on behavior and effectiveness of herbicides and persistence of control including residues in soils and plants

- Determine optimum times and rates of application, distribution patterns, formulations and mixtures for most effective use of herbicides

- Relate the percentage of defoliation to horizontal and vertical obscuration

- Study secondary succession of vegetation following different herbicidal treatments as related to "visibility"

- Investigate methods for improving absorption, translocation, and activity of herbicides

- Obtain botanical information needed to make correlations between the vegetation indigenous to the United States, Puerto Rico and Southeast Asia

RESEARCH RESULTS

All of the tasks enumerated in the APPROACH section were investigated and conclusions were drawn for each task. The principle finding of potential DoD interest was confirmation of the equal effectiveness of Tordon/Picloram compared to agent ORANGE. The research results tended to be rather basic in nature and were disappointing in view of the time and funding involved.

OPERATIONAL UTILITY

The research results, other than the botanical reports, did not become available until 18 months after the distribution of the "OCONUS Defoliation Test Program" (AD 486 540) report published by the U.S. Army Biological Center (AO 423). Since the USDA research confirmed rather than added to the earlier data and was produced by a civilian agency rather than a DoD component it is doubtful that any operational use was made of the results although wide distribution was made.

The two botanical reports had no apparent DoD utility since no operations outside Vietnam took place. The reports were stated to have been well received in the academic community and were said to have had basic scientific value.

The raw photographs and data from the botanical collection effort in Southeast Asia were requested by the Central Intelligence Agency who stated they found the data most useful.

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REPORTS

AD 629 181

VEGETATION OF SOUTHEAST ASIA, STUDIES OF FOREST TYPES, 1963-1965

by Llewelyn Williams. Dec 65. 302p. Report no. CR 49-65, U.S.
Dept. of Agriculture

Unclassified / Unlimited

AD 821 070

FORESTS OF SOUTHEAST ASIA, PUERTO RICO, AND TEXAS

by Llewelyn Williams. SEP 67. 410p. Report no. CR 12-67, U.S.
Dept. of Agriculture

Unclassified / Unlimited

AD 675 830

RESEARCH REPORT... RESPONSE OF TROPICAL AND SUBTROPICAL WOODY PLANTS TO
CHEMICAL TREATMENTS

by Fred H. Tschirley. Feb 68. 197p. Report no. CR 13-67, U.S.
Dept. of Agriculture

Unclassified / Unlimited

ARCHIVE LOCATION

Accession No. 73-A-882 , Box 5

Folder(s)

G11721 Herbicide Screen - 1967
G11722 Herbicide Toxicities - 1967
G11722 Defoliation - AO 424 1964-66
G11722 Defoliation Reports USDA AO 424
G11722 Defoliation Reports USDA 00424, 1966

Accession No. 71-A-1606 , Box 1

Folder(s)

Order No. 424 - Phytotoxic Chemicals

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PROGRAM TITLE

Assessment of Ecological Effects of Extensive or Repeated Use of Herbicides

ARPA ORDER 1086

FUNDING - \$62 K

Basic (FY68) - \$55,500

Amd 1 (FY68) - \$6,800

Amd 2 (FY68) - (-\$274)

PERFORMANCE PERIOD

August 1967 thru December 1967

ARPA PROGRAM MANAGERS

None - This was a DDR&E effort funded by ARPA

DDR&E PROGRAM MANAGER

A.E. Hayward

AGENT

Defense Supply Service-Washington (DSSW)

CONTRACTOR

Midwest Research Institute (MRI) - Contract No. DAHC15-68-C-0119

KEY CONTRACTOR PERSONNEL (Data valid 1968)

Dr. William B. House
Director of Biological Sciences
Midwest Research Institute
425 Volker Boulevard
Kansas City, MO 64110

OBJECTIVE

Assess the effects of extensive or repeated use of herbicides

APPROACH

DDR&E placed an extremely tight time frame on the effort since the report was needed for a meeting of the National Academy of Sciences (NAS) scheduled for late December 1967. Utilizing an array of seven MRI scientists and three consultants a total of 147 individuals were contacted

and their contributions evaluated, merged and edited to produce the report, in the specified 3 1/2 months.

RESEARCH RESULTS

The report, while not tightly edited due to the time constraints, represented a major contribution to the literature at the time of publication and even today represents a useful compendium of herbicidal data for 1966 and prior years. Major chapters in the report address civilian use, military use, toxicology, persistence of residues and projected ecological consequences.

OPERATIONAL UTILITY

No judgement can be made from the ARPA files since the report was produced for DDR&E use with NAS.

REPORTS

AD 824 314

ASSESSMENT OF ECOLOGICAL EFFECTS OF EXTENSIVE OR REPEATED USE OF HERBICIDES

by W.B. House, L.H. Goodson, H.M. Gadberry and K.W. Dockter. Dec 67, 371p. MRI Project No. 3103-B, Midwest Research Institute

Unclassified / Unlimited

ARCHIVE LOCATION

Accession No. 330-77-047 , Box 3

Folder(s)

Order No. 1086 - Study of Ecological Effects of Herbicides

CONSOLIDATED BIBLIOGRAPHY OF ARPA SPONSORED REPORTS

AD 476 961

VEGETATIONAL SPRAY TESTS IN SOUTH VIETNAM

by J.W. Brown. Apr 62. 119p. Unnumbered Report, US Army Biological Laboratories

Unclassified / Limited

AD 368 997

VEGETATIONAL SPRAY TESTS IN SOUTH VIETNAM, SUPPLEMENT

by J.W. Brown. Apr 62. 136p. Unnumbered Report, US Army Biological Laboratories

Unclassified / Limited

AD A950097

REVIEW AND EVALUATION OF ARPA/OSD "DEFOLIATION" PROGRAM

by Fred J. Delmore, Warren C. Shaw, Levi T. Burcham, Charles E. Minarik, Donald Whittam. May 62. 96p. Unnumbered Report, US Army Chemical Corps Research and Development Command

Unclassified / Unlimited

AD 478 189

MODIFICATION AND CALIBRATION OF DEFOLIATION EQUIPMENT (C-123 - FIRST MODIFICATION)

by James W. Brown. JULY 1962. 102p. Unnumbered Report, U.S. Army Biological Laboratories

Unclassified / Unlimited

AD 478 190

SUPPLEMENT TO MODIFICATION AND CALIBRATION OF DEFOLIATION EQUIPMENT (C-123 - FIRST MODIFICATION)

by James W. Brown. JULY 1962. 44p. Unnumbered Report, U.S. Army Biological Laboratories

Unclassified / Unlimited

AD 478 158

SPRAY TEST CALIBRATION OF THE HIDAL (HUS-1 or H-34)

by James W. Brown. JULY 1962. 76p. Unnumbered Report, U.S. Army Biological Laboratories

Unclassified / Limited

AD 442 477

CALIBRATION OF SPRAY SYSTEMS

C-123/MC-1

H-34/HIDAL

A-1H/FIDAL -

by Lester W. Boyer and James W. Brown. June 64. 110p. Report no. TR 46, U.S. Army Biological Laboratories

Unclassified / Unlimited

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AD 442 478

BASIC DATA
FROM C-123/MC-1 CALIBRATION TRIALS
1963

by Lester W. Boyer and James W. Brown. June 64. 354p. Report no. TR
46-Supplement I, U.S. Army Biological Laboratories
Unclassified / Limited

AD 442 479

BASIC DATA
FROM H-34/HIDAL CALIBRATION TRIALS
1963

by Lester W. Boyer and James W. Brown. June 64. 306p. Report no. TR
46-Supplement II, U.S. Army Biological Laboratories
Unclassified / Limited

AD 442 480

THE A1-H/FIDAL CONCEPT

by Lester W. Boyer and James W. Brown. June 64. 440p. Report no. TR
46-Supplement III, U.S. Army Biological Laboratories
Unclassified / Limited

AD 486 540

OCONUS DEFOLIATION TEST PROGRAM

by Robert A. Darrow, George B. Truchelet, Charles M. Bartlett. Jul 66,
149p. Report no. TR 79, U.S. Army Biological Center
Unclassified / Limited

AD 629 181

VEGETATION OF SOUTHEAST ASIA. STUDIES OF FOREST TYPES, 1963-1966

by Llewelyn Williams. Dec 65. 302p. Report no. CR 49-65, U.S. Dept.
of Agriculture
Unclassified / Unlimited

AD 821 070

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AD 675 830

RESEARCH REPORT... RESPONSE OF TROPICAL AND SUBTROPICAL WOODY PLANTS TO
CHEMICAL TREATMENTS

by Fred H. Tschirley. Feb 68. 197p. Report no. CR 13-67, U.S. Dept.
of Agriculture
Unclassified / Unlimited

AD 453 073

TEST AND EVALUATION OF THE A/A 45Y-2 PRESSURIZED DEFOLIANT DISPENSER

by Charles L. Flynn, Capt. USAF. Oct 64. 111p. Report no.
APGC-TR-64-72, Air Proving Ground Center, AFSC
Unclassified / Limited

AD 452 997

TEST AND EVALUATION OF THE A/A 45Y-2 PRESSURIZED DEFOLIANT DISPENSER
Supplement I - Tabulated Data

by Charles L. Flynn, Capt. USAF. Oct 64. 100p. Report no.
APGC-TR-64-72 (Suppl I), Air Proving Ground Center, AFSC
Unclassified / Limited

AD 350 588

DESIGN & EVALUATION OF AN INTERIM ANTICROP WEAPONS SYSTEM

by Carl R. Thayer. May 64, 81p. Report no. TR 47, U.S. Army
Biological Laboratories

CONFIDENTIAL (Release should be made by Dugway PG)

AD 824 314

ASSESSMENT OF ECOLOGICAL EFFECTS OF EXTENSIVE OR REPEATED USE OF HERBICIDES

by W.B. House, L.H. Goodson, H.M. Gadberry and K.W. Dockter. Dec 67,
371p. MRI Project No. 3103-B, Midwest Research Institute

Unclassified / Unlimited