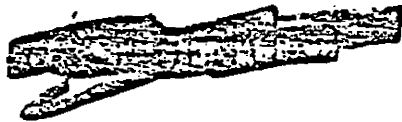


UNCLASSIFIED



UNCLASSIFIED

Regraded by authority of AR 380-86

on 7 Oct 81

by Robert E. Boyle

A PROGRAM FOR RESEARCH AND DEVELOPMENT

IN CHEMICAL DEFOLIATION OF VEGETATION (U)

HELMUTH L. BOONE, CSR

MAR 10 1963

EXHIBIT Hayward-3

prepared by

Crops Division

U. S. Army Biological Laboratories

Ft. Detrick, Maryland

November 16, 1962

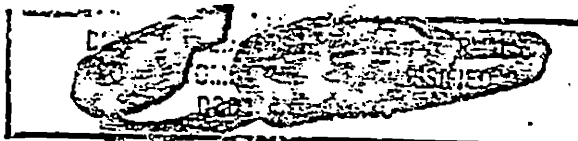
11352774

NOV 21 1962

Copy 3 of 4 copies



Serial 12



INTERNAL SECURITY

Emv-#749

UNCLASSIFIED

~~SECRET~~
INTRODUCTION

4) An urgent need has been recognized by the Department of Defense, for a chemical agent which will cause rapid defoliation of native or crop vegetation when applied at minimal dosages. The recent limited testing and use of high-volatile esters of 2,4-D and 2,4,5-T as interim defoliation agents in South Vietnam have emphasized the possibilities of such a method for increasing horizontal and vertical visibility in heavy vegetational cover so as to permit observations of enemy troops and material.

(U) Defoliation agents are growth-regulating chemicals which induce premature leaf-fall when applied to plants. They differ from systemic or contact herbicides in that death of the plant does not necessarily accompany defoliation. Normal defoliation of plants results from the formation of an abscission layer or shear zone at the base of the leaf blade or petiole, under the control of a hormonal mechanism. The ideal defoliation agent is then a hormone or growth-regulant chemical which induces rapid abscission. Other chemicals known as desiccants may cause death of foliage by dehydration or desiccation without accompanying leaf-fall.

(U) Research activities in the development of chemical agents for use as anticrop herbicides and defoliants have been the responsibility of the Crops Division of the U. S. Army Biological Laboratories. The accompanying plan of research points up the immediate and long range program proposed by the Crops Division in the development of a suitable defoliation agent and system for distribution under military use. Detailed information and budgetary requirements are furnished only for research proposed by the Crops Division; general requirements for systems development to be carried out by the Munitions Divisions and other agencies are indicated.

UNCLASSIFIED

UNCLASSIFIED

Previous Research of Crops Division

(U) A sustained program of investigations by the Crops Division of the U. S. Army Biological Laboratories at Fort (Camp) Detrick has led to the discovery and development of a wide array of growth-regulating chemicals for use as anticrop agents. In the period from World War II to 1957, especial emphasis was given to anticrop agents and to aerial methods for low-volume application. More than 15,000 chemicals were screened for their phytotoxic activity in this period. (See Appendix A for list of special reports and published papers of the Chemical Branch, Crops Division, 1945-57).

(U) Butyl esters of 2,4-D and 2,4,5-T were selected as anticrop agents because of their extreme phytotoxicity at low rates and their specific action of broadleaf crops and vegetation. In 1958, cacodylic acid (CA) was reported to be effective in preventing maturity of rice when applied at rates of 0.25 lb/A; at higher rates (5 to 10 lb/A), CA was effective in desiccation of most kinds of vegetation (1).

(U) In 1958, 2,4,5-T and a mixture, "purple", of 2,4-D and 2,4,5-T esters were sprayed aerially for forest vegetation control at Camp Drum, New York. Rates of approximately 1 gallon per acre were effective in defoliation and control of most hardwood species in these tests. Due to subsequent curtailment of funds, no further defoliation studies were made until 1961.

(U) In early FY 1962, an in-house screening program of defoliation agents was initiated and a synthesis contract was negotiated with the Illinois Geological Survey for synthesis of fluorinated compounds. By late 1961 and 1962 additional funds were provided for interim tests and supervision of operational applications of herbicides for defoliation in South Vietnam by Dr. J. W. Brown (2), for modification of aircraft equipment

UNCLASSIFIED

~~UNCLASSIFIED~~

(3,4,5) and for an expansion of the contract research program for synthesis of chemicals as possible defoliant agents.

Evaluations of tests and operational applications of interim defoliants in South Vietnam were made in February, 1962 by Brown (6), by a 5-man evaluation team headed by General Fred Delmore, Commanding General, U. S. Army CER Agency, in April, 1962 (7), and in August and September 1962 by Delmore and Minarik (8).

(U) Scope of Present Research Program in Defoliation of Crops Division

1. (U) Synthesis and screening of new chemicals for defoliants under contract research.

Contracts funded during FY 1962 include:

Pennsalt Chemical Corporation, 1 year contract for synthesizing and screening approximately 1,000 compounds	\$464,000
---	-----------

Ethyl Corporation, 6 month contract for synthesis and screening 300 compounds	\$66,000
---	----------

Ansul Chemical Corporation, 1 year contract for synthesis of arsenic-organic compounds	\$45,000
--	----------

Illinois Geological Survey, 1 year contract for synthesis of fluorine-containing compounds	\$20,000
--	----------

BioSearch and Development Company, 1 year contract for screening submitted chemicals on 6 woody species	\$38,000
---	----------

Negotiations are underway for an additional contract for the synthesis of defoliants by Monsanto Chemical Corporation for approximately \$500,000 to be funded in FY 1963.

0357701

2. (U) Contracts for fundamental research

University of California at Davis (Dr. Addicott), continuing contract for the isolation and characterization of abscisin, a natural plant hormone causing abscission. \$30,000

3. (U) In-house screening and field testing program

All chemicals received under synthesis contracts and the ILO program undergo a primary screening for anticrop activity. Active compounds are then subjected to defoliation screening on bean plants and on six woody species under greenhouse conditions.

Field tests have been made by injection applications into tree trunks at Fort Ritchie; field plantings of nursery stock have been made for subsequent field tests.

4. (U) South Vietnam program

Dr. L. E. Minarik, Chief, and Dr. J. W. Brown, Deputy Chief, Crops Division, have each spent several months in South Vietnam in supervision and evaluation of operational and test applications of defoliants (2,6,7,8).

5. (U) Aircraft equipment modification

Calibration tests of the C-123 and HIDAL equipment were conducted at Eglin A.F.B. in Florida in June 1962; a second calibration series has been scheduled for November 1962 (3,4,5).

PROPOSED PROGRAM

Objective

Primary

1. (U) To determine effective chemical agents which will cause rapid defoliation of vegetation
2. (U) To develop appropriate distribution systems for chemical defoliant agents.

UNCLASSIFIED

Corollary

3. (U) To determine effective dose rates, volumes and conditions for application of selected agents in various vegetational types.
4. (U) To determine ecological and physiological conditions affecting defoliation of various kinds of plants by selected agents.
5. (U) To assemble background information on the vegetational composition and ecological conditions of various vegetational and crop areas of the world pertinent to effective use of selected defoliant.

Program Phases

(U) The proposed plan outlines research operations and personnel and budgetary requirements for these time-periods: (A) Immediate (January 1963 to July 1963); (B) Intermediate (January 1963-July 1964); (C) Long-range (1964-1968)

Budgetary requirements, unless otherwise specified, are for total research program including currently budgeted funds.

A. Immediate (January 1963-July 1963)

Research program

1. (U) Field testing of interim defoliant agents in Thailand.

A testing and evaluation team should be assembled not later than 1 April 1963 for defoliation tests with available chemicals in Thailand in vegetation types comparable to those of South Vietnam. The team would be headed by a military officer and consist of 5 civilian technicians and a complement of Thai and U.S. military personnel.

(U) The team would conduct applications of defoliants with C-123, H-34, AC-6 and other available aircraft, evaluate plant response and make necessary modifications of aircraft and ground distribution equipment.

UNCLASSIFIED

UNCLASSIFIED

~~SECRET~~
Interim defoliant chemicals available for the Thailand testing program are as follows:

Recommended

1. Combinations of butyl esters of 2,4-D and 2,4,5-T
2. 2,4,5,-T ester
3. Cacodylic acid

Additional suggested chemicals,

4. 2,3,6,-TBA

(U) Commercial formulations contain 2 or 4 lb/gal.; cost approximately \$5.00 per pound. Suggested rate 4 to 6 lb/A/

5. (U) Dinitro or pentachlorophenol

Dinitros available under trademark Dow General, Sinox General, etc. Primarily contact or desiccant herbicides, to be used in mixtures with diesel fuel at rates of 1-2 quarts dinitro per 5 to 10 gallons of oil and 1-1½ gallons pentachlorophenol per 3 to 6 gallons of solution. Costs \$2-4 per gal.

6. (U) Ammate

For heavy-rate applications in ground equipment using high volumes of water. 1 lb/gal and 200 to 400 gals/A. Not suitable for aerial application. Cost about \$0.30 per pound. Corrosive to equipment.

7. (U) Endothal

An effective cotton defoliant, not thoroughly evaluated on woody plants; used at 1-2 gals/A in 5-10 gals of water for crop plant defoliation. Other cotton defoliants include DEF (S,S,S-tributylphosphorothioate) and FOLEX (tributyl phosphorotrithioate) which are applied at rates of 1-2 quarts in 5 to 10 gallons of water.

~~SECRET~~
6
UNCLASSIFIED

0352784

8. (U) Diquat

An extremely active chemical with good defoliant and desiccant activity. Of limited availability; available in experimental quantities from California Chemical Company.

2. (U) In-house screening and field evaluation

Greenhouse screening program will be expanded with the addition of a screening supervisor and technician.

Screening tests will be initiated on field plantings of nursery stock.

Field tests with ground and aerial equipment with selected agents will be conducted at Fort Ritchie, Camp Drum and other locations.

3. (U) Contract synthesis

Existing contracts will be continued; negotiations will be completed for yearly synthesis of 300 additional compounds.

Renewed contracts will incorporate screening tests on selected woody species.

Additional personnel will be designated to monitor synthesis contracts and to develop effective information retrieval system for handling chemical and plant response data.

4. (U) In-house basic research

Fundamental studies of mechanism of abscission and of mode of action of defoliant agents will be initiated by two new plant physiologists.

Personnel

1. (U) Current civilian personnel assigned to the chemical defoliation program include Dr. J. W. Brown, Deputy Chief; Dr. R. A. Darrow, GS-14, Chemical Branch; L. W. Boyer, GS-11. Military personnel include, Lts. Bird, Quibell, Bertram and Francis and enlisted men, Frank, Buschmann and

UNCLASSIFIED

Korneweck.

2. (C) Testing and evaluation team for Thailand

2 agronomists or plant physiologists, GS-11 and 9

2 agricultural or aeronautical engineers, GS-11

1 botanist or taxonomist familiar with tropical vegetation, GS-9 or 11

(A) Budget Requirements

Budget requirements in excess of funds already allocated for FY 1963 are as follows:

In-house screening, field testing and basic research, Contract monitoring

Personnel \$15,000

Equipment and maintenance 60,000
\$75,000

Thailand field testing and evaluation

Personnel 15,000

Overhead, travel, equipment 100,000
\$115,000

Contract synthesis \$150,000

Total, Crops Division \$340,000

Aircraft equipment modification and systems development \$150,000

B. Intermediate (January 1963-July 1964)

Research phases

(U) Emphasis will be placed on the development of an interagency agreement between Crops Division and the Agricultural Research Service of USDA in an expanded program of secondary screening of defoliant compounds, and in basic research in defoliation and abscission. Synthesis contract research will be expanded to review greater numbers of chemicals. Field testing programs will be expanded in tropical and temperate areas. Both in-house and contract programs in fundamental research on defoliation and abscission will be strengthened.

1. (U) Proposed cooperative agreement with Crops Protection Division, Agricultural Research Service.

Effective broadening and strengthening of some phases of the Crops Division defoliation research program can be secured by cooperation with the Crops Protection Division, Agricultural Research Service, U. S. Department of Agriculture. The proposed research would be carried out under an interagency agreement between the Crops Division and the Crops Protection Division of USDA. Funding would be effected through the U. S. Army Biological Laboratories.

Suggested phases in this cooperative program are :

a. Secondary screening of candidate chemical agents in woody plant nurseries in Texas and Arizona.

b. Field testing of chemical agents in various temperate zone locations including Washington, Nevada, California, Utah, Texas, Arizona, Nebraska, and Georgia. Rate, volume, and season of application studies would be conducted at a level requiring 4 to 6 full time technical personnel.

Field testing of chemical agents under tropical and subtropical conditions would be conducted in Florida and Puerto Rico, requiring 2 full-time technicians.

d. Fundamental research on environmental factors affecting defoliation and action of chemical defoliation agents would be conducted at Beltsville requiring 1 or 2 full time plant physiologists.

e. Engineering assistance in the development of aircraft application systems would be available on a consultant basis.

The proposed research effort of the U. S. Department of Agriculture group would be projected on a 2 to 5 year basis.

2. (U) In-house screening and field testing

Increased personnel and greenhouse facilities will be needed for review of synthesized compounds. Nursery field screening tests will be upgraded.

An additional field testing and evaluation team will be developed for tests of agents and equipment in tropical and sub-tropical areas, including Panama and Mexico. The team would work at several locations on a rotational basis.

Monitor teams of chemist and plant physiologist would be established to handle contract syntheses liaison. The monitor team would cooperate closely with the Biomathematics Division in the development of information retrieval systems to record assembled data on chemicals and plant response. An additional technician might be assigned to this phase if available.

3. (U) In-house basic research

Capability will be developed for studies in the mechanism of abscission and defoliation and of environmental and internal variables influencing normal or induced defoliation.

4. (U) Contract research on synthesis and screening

Present contracts will be renewed or renegotiated to maintain a capability of production of 1500 - 2000 compounds yearly. Primary Screening on woody plants will be included in contracts.

5. (U) Contract research on defoliation

Existing contracts with the University of California on isolation and characterization of abscisin will be continued. Additional contract with Dr. Leopold at Purdue University on mechanism of abscission will be developed.

0352700

Personnel

(a) Additions to civilian personnel (FY 1964)

Screening and field testing

2 agronomists or plant physiologist, GS-7 or 9

1 plant physiologist, GS-11 and

1 organic chemist, GS-11 (indicated on immediate program) as
monitor team for contract synthesis

Field evaluation team - tropical

1 agronomist or physiologist GS-9 or 11

1 ecologist or taxonomist, GS-9 or 11

1 agricultural engineer, GS-7-11

In-house basic research

2 plant physiologist GS-9 or 11

0352789

UNCLASSIFIED

(U) Budget Requirements

Complete budget requirements for the Crops Division defoliation program for FY 1964:

In-house screening and field testing including evaluation team for tropics; additional greenhouse facilities	\$350,000
In-house basic research program	100,000
Contract synthesis of chemicals and screening	1,500,000
Contract research on abscission and defoliation	80,000
Interagency agreement with U.S. Department of Agriculture for field testing and basic research on defoliation	250,000
Field testing and evaluation in Thailand	250,000
Total, Crops Division	\$2,530,000

Long-Range Program (1963-1968)

Research phases (U)

(K) By the end of FY 1964 or early 1965, it is anticipated that synthesis programs, screening and field testing programs will have been expanded to desired capacity. Shift in emphasis in chemical agents may be made to a dry-type agent, assuming that effective liquid agents are secured. Field testing programs will be shifted in location to secure diversified vegetational areas.

(U) Basic research capability will be strengthened with both in-house and cooperative USDA effort on hormonal mechanism studies of defoliation. Isolation and syntheses of natural defoliation hormones may be achieved.

1. (U) Contract synthesis and screening of chemicals

Contracts will be renewed and/or negotiated for development and standardization of a liquid defoliant and for a universal dry-type defoliant. Synthesis of new compounds will be continued for possible agents in aerial and ground equipment of both liquid and dry-type chemicals. Emphasis will also be given to soil sterilant herbicides. Synthesis capability of 2000 compounds yearly will be established for contracts.

2. (U) Screening and field testing

Screening programs under greenhouse and controlled conditions will be continued. Field testing will be conducted in temperate and tropical areas in diversified vegetation types.

Emphasis in screening may shift from liquid to dry-type chemicals.

3. (U) Cooperative research with U.S. Department of Agriculture Field evaluation program and fundamental research studies will be continued as outlined under the Intermediate Program.

4. (U) In-house program of basic research

Capability will be developed for securing fundamental and background information on the mechanism of action of defoliants, desiccants, and herbicides.

Proposed research will include:

Use of radioactive tracer techniques in absorption and translocation studies; biochemical analysis of metabolic changes in natural abscission and that induced by application of chemical agents.

Studies on the environmental and internal controls of plant response to application of growth-regulant chemicals; senescence and aging of leaves of plants from various tropical and temperate climates in relation to natural or induced defoliation.

Development of ecological background information on the species composition and responses of plants in various vegetation types to defoliant and herbicide application.

5. (U) Contract program of basic research

Isolation, characterization and, if possible, synthesis of natural abscission-inducing hormones (abscisin) will be carried out. Experiments with the naturally-occurring abscission hormones will greatly facilitate an understanding of the process and the conditions favorable to defoliation.

6. (U) Development and modification of equipment

It is anticipated that subsequent modification of aerial and ground equipment may be needed to accommodate to the type of agent standardized-liquid or dry-type to meet future requirements.

(4) Equipment should be developed for three types of aircraft: (1) helicopters and fixed wing craft of minimum speed; (2) aircraft of medium speed, with large and small tank or storage capacity of agent; and (3) fast-speed aircraft. Use of the latter may be feasible for dissemination of anticrop chemical and biological agents; their use is not foreseen in the defoliation program because of the apparent higher rates per acre required.

Personnel

(4) Additional civilian personnel needed for FY 1965-1968:

2 agronomists or plant physiologists for screening and field testing, GS-7 or 9

4 plant physiologists and biochemists for in-house basic research, GS-9-12

Budgetary Requirements

Complete yearly budget requirements for Crops Division defoliation program in FY 1965-1968:

In-house screening and field testing additional greenhouse facilities \$275,000

In-house basic research program 250,000

Contract synthesis of chemicals and screening 1,700,000

Contract research on abscission and defoliation 120,000

Field testing in tropical areas 150,000

Interagency agreement with U.S. Department of Agriculture for field testing evaluation and basic research 275,000

Total: Crops Division \$2,770,000

Approximate cost of Development of distribution systems including liquid and dry-type agent dissemination by air and ground equipment \$500,000

2677000

~~CONFIDENTIAL~~

4 Budgetary Requirements

Complete yearly budget requirements for Crops Division defoliation program in FY 1965-1968:

In-house screening and field testing additional greenhouse facilities \$275,000

In-house basic research program 250,000

Contract synthesis of chemicals and screening 1,700,000

Contract research on abscission and defoliation 120,000

Field testing in tropical areas 150,000

Interagency agreement with U.S. Department of Agriculture for field testing evaluation and basic research 275,000

Total: Crops Division \$2,770,000

Approximate cost of Development of distribution systems including liquid and dry-type agent dissemination by air and ground equipment \$500,000

CONFIDENTIAL

LITERATURE CITED

1. Technical Report EWL 6, Confidential

is potentialities of cacodylic acid as an anticrop agent (U). by Charles E. Hess, U. S. Army Chemical Corp, Biological Warfare Laboratory, Fort Detrick Maryland, April 1958.

2. Trip Report, Secret

Trip Report - South Vietnam (U). by J. W. Brown, Crops Division, U. S. Army Chemical Corps, Biological Laboratory, Fort Detrick, Maryland, 19 December 1961.

3. Report, Unclassified

Modification and calibration of defoliation equipment (C-123 First Modification). Joint report by personnel of USDA, USAF and USA CMLC of work performed under OSD/ARPA order 256, Amendment 4. by J. W. Brown and Donald Whittam, U. S. Army Biological Laboratory, Fort Detrick, Maryland, July 1962.

4. Report, Unclassified

Supplement to Modification and Calibration of Defoliation equipment (C-123 First Modification) by James W. Brown and Donald Whittam, U. S. Army Biological Laboratory, Fort Detrick, Maryland, July 1962.

5. Report, Unclassified

Spray test calibration of the HIDAL (HUS-1 or H-34). Report prepared under OSD/ARPA order 256 Amendment 4, by J. W. Brown. U. S. Army Biological Laboratory, Fort Detrick, Maryland, July 1962.

6. Special Report, Secret

Vegetational spray tests in South Vietnam. Supplement, (U). by J. W. Brown, U. S. Army Biological Laboratory, Fort Detrick, Maryland, April 1962.

7. Report, Unclassified

Review and evaluation of ARPA/OS. Defoliation Program in South Vietnam" by General Fred J. Delmore, W. C. Shaw, C. E. Minarik, L. T. Burcham and Donald Whittam. U. S. Army, CBR Agency, April 1962.

8. Special Report, Secret

Man Peninsula Defoliation Operations, September - October 1962, in Report of South Vietnam by General Fred J. Delmore, and C. E. Minarik, U. S. Military Assistance Command Vietnam, Saigon, Vietnam, October 1962.

0352794

APPENDIX A

Fort Detrick Special Reports

1. Special Report 12, "Crop Destruction by Aerial Sprays. Preliminary Trials; Bushnell Army Air Field, February to April 1945 (U)," Special Projects Division, Camp Detrick, Frederick, Maryland. April 1945. CONFIDENTIAL.
2. Special Report 13, "Marking and Defoliation of Forest Vegetation (U)," Crops Division, Camp Detrick, Frederick, Maryland. May 1945. CONFIDENTIAL.
3. Special Report 14, "The Effect of VKA and VKS on Natural Vegetation, Preliminary Trials, Bushnell Army Air Field, February to April 1945," Special Projects Division, Camp Detrick, Frederick, Maryland. June 1945. UNCLASSIFIED.
4. Special Report 25, "Crop Destruction by Aerial Sprays. Field Trials, 1945. Vigo Plant CWS, Terre Haute, Indiana and Beaumont, Texas, April to October 1945 (U)," Crops Division, Camp Detrick, Frederick, Maryland. October 1945. CONFIDENTIAL.
5. Special Report 64, "Destruction of Tropical Crops with Growth-Inhibiting Agents (Chemical Defense Research Establishment, Carmanore and Kumble, South India) (U)," Special Projects Division, Camp Detrick, Frederick, Maryland. May 1945 to February 1946. CONFIDENTIAL.
6. Special Report 78, "Observations on the Permanent Effects of Aerial Plant Growth Inhibitory Sprays Upon Natural Vegetation (Vigo Plant, Chemical Corps, Terre Haute, Indiana), Crops Division, Camp Detrick, Frederick, Maryland. Aug 1946. UNCLASSIFIED.
7. Special Report 79-I, "Crop Destruction by Chemical Agents, Part I (U)," Crops Division, Camp Detrick, Frederick, Maryland. November 1947. CONFIDENTIAL.
8. Special Report 79-II, "Crop Destruction by Chemical Agents, Part II (U)," Crops Division, Camp Detrick, Frederick, Maryland. November 1947. CONFIDENTIAL.
9. Special Report 79-III, "Crop Destruction by Chemical Agents, Part III (U)," Crops Division, Camp Detrick, Frederick, Maryland. November 1947. CONFIDENTIAL.
10. Special Report 86, "Plant Growth Inhibitors (LN Agents) for Crop Destruction (U)," Crops Division, Camp Detrick, Frederick, Maryland. July 1947. CONFIDENTIAL.

0352795

11. Special Report 92, "Field Plot Experiments with Plant Inhibitors 1946 and 1947 Seasons (U)," Crops Division, Camp Detrick, Frederick, Maryland, February 1948. CONFIDENTIAL.
12. Special Report 105, "Field Plot Experiments with Plant Inhibitors 1948 Season (U)," Crops Division, Camp Detrick, Frederick, Maryland. 16 Aug 1949. CONFIDENTIAL.
13. Special Report 130, "Field Plot Experiments with Plant Inhibitors, 1949 Season (U)," Crops Division, Camp Detrick, Frederick, Maryland. 14 April 1950. CONFIDENTIAL.
14. Special Report 149, "Low Volume Anticrop Aerial Spray Trials, Phase I (U)," Crops Division, Camp Detrick, Frederick, Maryland. May 1951. CONFIDENTIAL.
15. Special Report 151, "Low Volume Anticrop Aerial Spray Trials, Phase II (U)," Crops Division, Camp Detrick, Frederick, Maryland. 20 December 1951. CONFIDENTIAL.
16. Special Report 153, "Field Plot Experiments with Plant Inhibitors 1950 Season (U)," Crops Division, Camp Detrick, Frederick, Maryland. 21 June 1951. CONFIDENTIAL.
17. Special Report 156, "Field Plot Experiments with Plant Inhibitors, 1950 and 1951 Season (U)," Crops Division, Camp Detrick, Frederick, Maryland. December 1952. CONFIDENTIAL.
18. Special Report 200, "Field Development of Chemical Anticrop Agents: 1 Preliminary Field Evaluation of Chemical Agents for Attacking Wheat (U)," Crops Division, Camp Detrick, Frederick, Maryland, February 1954. SECRET (54-BL-723).
19. Special Report 201, "Field Development of Chemical Anticrop Agents: 2. Response of Field Grown Crops to Chemical Anticrop Agents Released from an Experimental Spray Tower (U)," Crops Division, Camp Detrick, Frederick, Maryland. January 1954. SECRET (54-BL-788).
20. Special Report 232, "Some Effects of Altitude and Airspeed on the Behavior of Chemical Anticrop Aerial Sprays (U)," Crops Division, Camp Detrick, Frederick, Maryland. June 1955. SECRET (55-CD-1128).
21. Special Report 234, (Title Confidential) Crops Division, Fort Detrick, Frederick, Maryland. May 1955. SECRET (55-CD-802)
22. Special Report 256 by McLane, S. R. and E. W. Dean. (Title classified). Crops Division, Camp Detrick, Frederick, Maryland. December 1955. SECRET. (56-CD-16)

0352796

23. Special Report 262, (Title classified) by E. W. Dean, and S. R. McLane, Crops Division, Fort Detrick, Frederick, Maryland. October 1956. CONFIDENTIAL.

Interim Reports

1. Interim Report 94, "Defoliation, Target Marking and Its Implications (U)", Crops Division, Camp Detrick, Frederick, Maryland, June 1955. CONFIDENTIAL.
2. Interim Report 140, "Defoliation Investigations During 1954 and 1955 (U)", Crops Division, Fort Detrick, Frederick, Maryland. October 1956. CONFIDENTIAL.

Status Report No. 53-6, (Title classified) by Minarik, C. E., Crops Division, Camp Detrick, Frederick, Maryland. 15 May 1953. SECRET (54-BL-1371)

0352/97

Published Papers

- Reprint No. 70. Newman, A. S., W. Fones and N. Renoll. "New Compounds as plant growth regulators". Jour. Am. Chemical Society. 69:718-723, March 1947.
- Reprint No. 112. Ennis, W. B. "Responses of crop plants to O-isopropyl N-phenyl carbamate". Bot. Gaz. 109:4473-493, June 1948.
- Reprint No. 120. DeRose, H. R., and Newman, A. S. "The comparison of the persistence of certain plant growth regulators when applied to soil". Soil Sci. Soc. of America Proceedings. 12:222-226, 1947.
- Reprint No. 122. Newman, A. S., DeRose H. R. and DeRigo, H. T. "Persistence of isopropyl N-phenyl carbamate in soil". Soil Sci. 66:5:393-397, November 1948.
- Reprint No. 121. Newman, A. S. "The effect of certain plant growth regulators on soil micro-organisms and microbial processes." Soil Sci. Soc. of Am. Proceedings. 12:218-221, 1947.
- Reprint No. 125. Watson, D. P. "An anatomical study of the modification of bean leaves as a result of treatment with 2,4-D." Am. Jour. of Botany. 35:9: 543-555, November 1948.
- Reprint No. 138. Addicott, F. T., Lynch, R. S., Livingston G. A., and Hunter, J. K. "A method for the study of foliar abscissions in Vitro". Plant Physiol. 24:3:537-539, July 1949.
- Reprint No. 144. Eames A. J. "Histological effects of treatments with growth regulating substances of the 2,4-D group". Science. 110:2853-235-236, Sep 1949.
- Reprint No. 143. Wood, D. C. and W. B. Ennis. "Influence of Butyl 2,4,5-trichlorophenoxyacetate upon the development of tuber abnormalities in Irish potatoes." Agronomy Jour. 41:7:304-308, July 1949.
- Reprint No. 145. Weintraub, R. L. and A. G. Newman. "Plant growth-regulators". Economic Botany. 3:3:289-298, July - Sep 1949.
- Reprint No. 156. Weintraub R. L. and J. W. Brown. "Translocation of exogenous growth regulators in the bean seedling". Plant Physiol. 25:1:140-149, 1950.
- Reprint No. 157. Eames, A. J. "Comparative effects of spray treatments with growth regulating substances on the nut grass, *Cyperus rotundis* L. and anatomical modifications following treatment with Butyl 2,4-dichlorophenoxyacetate." Am. Jour. Bot. 36:8:571-584, October 1949.
- Reprint No. 168. Weintraub R. L., J. W. Brown, J. N. Yeatman. "Recovery of growth regulator from plants treated with 2,4-D". Science. 111(2888):493-494, May 1950.
- Reprint No. 172. Brown, J. W. and R. L. Weintraub. "A leaf repression method for evaluation of formative activity of plant growth regulating chemicals". Bot. Gaz. 111(4): 448-456, June 1950.

Reprint No. 188. Newman A. S. and J. E. Thomas. "Decomposition of 2,4-D in soil and liquid media". Proc. Soil Sci. of Am. 14:160-164, 1949.

Reprint No. 200. Ennis, W. B. and D. F. James. "A simple apparatus for producing droplets of uniform size from small volumes of liquids". Sci. 112 (2911) 434-436, October 13, 1950.

Reprint No. 204. Eames, A. J. "Persistence of 2,4-D in Plant Tissues. Science 112:601-602, November 17, 1950.

Reprint No. 211. Shoji, K., F. T. Addicott, and W. A. Swets. "Auxin in relation to leaf blade abscission". Plant Physiol. 26:1:189-191, January 1951.

Reprint No. 215. DeRose, H. R. "Crabgrass inhibitor with O-isopropyl N-(3-chlorophenyl) carbamate". Agron. Jour. 43(No. 3):139-142, March 1951.

Reprint No. 216. Eames A. J. "Destruction of phloem in young bean plants after treatment with 2,4-D". A. Jour. Botany, 37(10):840-47, December 1950.

Reprint No. 234. Eames A. J. "A correlation of severity of 2,4-D injury with stage of ontogeny in monocot stems". Science 114(2956) 203, August 24, 1951.

Reprint No. 241. Weintraub, R. L., James W. Brown, J. A. Throne, and J. N. Yeatman. "A method for measurement of call-elongation-promoting activity of plant growth-regulators". Am. Jour. Bot. 38:6:435-440, June 1951.

Reprint No. 248. Eames, A. J. "Leaf ontogeny and treatments with 2,4-D". Am. Jour. Bot. 38:10:777-780, December 1951.

Reprint No. 251. Addicott, F. T., and R. S. Lynch. "Acceleration and Retardation of abscission by indoleacetic acid". Science, 114(2974):668-689. 28 December 1951

Reprint No. 269. Newman, A. S., Thomas, J. E. and Walker, R. L. "Disappearance of 2,4-D and 2,4,5-T from soil". Soil Sci. Proc. 16(1):21-24, January 1952.

Reprint No. 270. Ennis, W. B. Jr. "Influence of different carriers upon the inhibitory properties of growth-regulatory sprays". Weeds. 1(1):43-47, Oct, 1951.

Reprint No. 271. Minarik, C. E., Norman, A. G., Thompson, H. E. and Owings, J. P. Jr. "New growth regulating compounds. II. Substituted Benzoic acids". Bot. Gaz. 113:135-147, December 1951.

Reprint No. 276. Weintraub, R. L., Brown, J. W., Fields M. and Rchan J. "Metabolism of 2,4-D. I. $C^{14}O_2$ production by bean plants treated with labelled 2,4-D". Plant Physiol. 27:2:293-301, April 1952.

Reprint No. 281. Weintraub, Brown, J. W., Nicheray, and Taylor. "Studies on the relating between molecular structure and physiological activity of plant growth-regulators I. Abscission-inducing activity." Bot. Gaz. 113(3):348-361, March 1951.

Reprint No. 284. Bradbury, D. and W. B. Ennis Jr. "Stomatal closure in kidney bean plants treated with ammonium 2,4-D acetate." A. J. Bot. 39:324-328, May 1952.

Reprint No. 285. Freiburg, S. R. and H. E. Clark. "Effects of 2,4-D upon the nitrogen metabolism and water relations of soybean plants grown at different nitrogen levels." Bot. Gaz. 113(3):323-333, March 1952.

Reprint No. 291. Norman, A. G., and R. L. Weintraub. "Structure-activity relationships in plant growth regulators". U. S. Army Biological Laboratories Fort Detrick, Frederick, Maryland.

Reprint No. 299. Brown J. W. and R. L. Weintraub. "Influence of temperature on formative response of bean seedlings to 2,4-D." Bot. Gaz. 113(4): 479-482, 1952.

Reprint No. 316. Siegel and Weintraub. "Inactivation 3-indoleacetic acid". Physiol. Fl. 5:241-247, 1952.

Reprint No. 323. Weintraub R. L., Yeatman, J. N., Lockhart, J. A., and Reinhart, J. H., Fields M. "Metabolism of 2,4-D. II. Metabolism of the side chain by bean plants." Archives of Bioch. and Biophys. 40(2):297-285, October 1952.

Reprint No. 349. Weintraub R. L. "Mechanisms of action" Agr. & Food Chem. 1(3):250-254, 1953.

Reprint No. 351. Minarik C. E. and Norman, A. G. "Herbicides-chemical weed Control". Agr. and Food Chem. 1(1):42-44, April 1953.

Reprint No. 382. Bradbury, D., and Ennis W. B. Jr. "Histological abnormalities of tubers formed on Irish potato plants sprayed with butyl 2,4,5-T." A. J. Bot. 40(10) 827-834, 1953.

Reprint No. 420. McLane, S. R., Dean E. W., Brown, J. W., Connell C. R. Howard H. W., Minarik, C. E. "Halogenated phenyl alkyl ethers as plant growth regulators". Weeds, 2(4). October 1953.

Reprint No. 421. Newman, A. S. and H. T. DeRigo. "Isopropyl N-phenyl carbamate". Weeds 2(3):169-177 July 1953.

Reprint No. 433. Weintraub R. L., Reinhart, J. H., Scherff, R. A. and Schisler, Lee C. "Metabolism of 2,4-D. III. Metabolism and persistence in dormant plant tissue." Plant Physiol. 29(3): 303-304, 1954.

Reprint No. 438. Weintraub, R. L., Brown, J. W., Throne, J. A. "Relation between molecular structure and physiological activity of plant growth regulators II. Formative activity of phenoxycetic acids." Agr. and Food Chem. 2(19):996-999, 1954.

Reprint No. 502. Ready D. and Minarik C. E. "New growth regulating compounds IV. Selected toloxyacetic acids". Weeds. III. (3), July 1954.

Reprint No. 601. Anderson, Bachmann, McLane and Dean. "Inhibiting of plant growth by some nitrophenylureas." Weeds. 5(2):135-136, 1957.

Reprint No. 617. Aldrich and McLane. "A Paper chromatographic method for the detecting of 30amino-1,2,4-Triazole in plant tissue." Plant Physiol 32(2): 153-154. 1957.

0352800

Reprint No. 620. Lockhart, J. A., and Weintraub, R. L. "Influence of 2,4-D on sucin content of bean seedlings". A. J. Botany, 44(5):424-428, May 1957.

Reprint No. 652. Anderson, E. R. and McLane S. R. "Control of annual bluegrass and crabgrass in turf with fluorophenoxyacetic acids". Weeds, 6(1):52-58, 1958.

Reprint No. 667. Orgell, W. H. and Weintraub R. L. "Influence of some ions on foliar absorption of 2,4-D". Bot. Gaz., 119 (2):88-93, 1957.

11357801

~~CONFIDENTIAL~~

HEADQUARTERS
UNITED STATES ARMY BIOLOGICAL LABORATORIES

FORT DETRICK, FREDERICK, MARYLAND

SMUFD-5

15 November 1962 ✓

SUBJECT: Defoliant Program Requested by ARPA

5 Feb. - AMC

TO: Commanding General
U. S. Army CBR Agency
Army Chemical Center, Maryland

s.d.

During a recent visit to the U. S. Army Biological Laboratories, Dr. G. V. Mock, Assistant Director of ARPA, and Dr. Heaston, also of ARPA, requested that a program in chemical defoliation be prepared for the use of ARPA. The program as requested is forwarded herewith for transmittal.

FOR THE COMMANDER:

1 Incl
as


A. E. HAYWARD
Chief, Program Coordination Office

Copy furnished:
Dr. G. V. Mock

0 2 2 2
HE70000-1543

NOV 51 1 28 VII .ES

THIS DOCUMENT IS DOWN-GRADED TO
Unclass WHEN SEPARATED
FROM OTHER CLASSIFIED DOCUMENTS

1242

ARPA Cont. No.

Emv # 749

~~CONFIDENTIAL~~
UNCLASSIFIED

00000000

UNCLASSIFIED

SMUCB-TO-BW (15 Nov 62) 1st Ind
SUBJECT: Defoliant Program Requested by ARPA

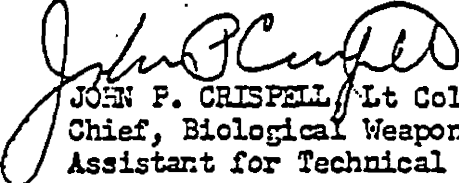
HEADQUARTERS U. S. ARMY CHEMICAL-BIOLOGICAL-RADIOLOGICAL AGENCY, Army
Chemical Center, Maryland 27 NOV 1962

TO: Commanding General, U. S. Army Munitions Command, ATTN: AMSU-R,
Dover, New Jersey

Attached program for defoliation submitted by U. S. Army Biological
Laboratories is forwarded herewith.

FOR THE COMMANDER:

1 Incl
nc (4 cys)


JOHN P. CRISPELL, Lt Colonel, CmlC
Chief, Biological Weapons Division
Assistant for Technical Operations

0352803

Rec Nr Free
Rec 11/29/62
Rec 8-384
Rec Nr 80-62

1242
IRPT Cont. No. 1242

When the accompanying classified
papers are withdrawn this paper
becomes **UNCLASSIFIED**

2

Em #749

UNCLASSIFIED

UNCLASSIFIED

11/26/62

AMSMU-RE (15 Nov 62) 2nd Ind (U)
SUBJECT: Defoliant Program Requested by ARPA (U)

Headquarters, U. S. Army Munitions Command, Dover, New Jersey DEC 20 '62

TO: Commanding General, U. S. Army Materiel Command, ATTN: AMCRD-DE-CB,
Washington 25, D. C.

Forwarded for your information, retention and further transmittal.

FOR THE COMMANDER:

w/d 1 copy of Incl

Eugene F. Loring
St. Louis

DALE L. VINCENT
Colonel, GS
Chief, CBR Operations Office

0352806

UNCLASSIFIED

1242

ARPA Cont. No.