US Army Corps of Engineers

Preliminary Archives Search Report Findings for Use / Testing of 2,4,5-T Compounds

Fort Detrick

Frederick, MD

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Prepared by
U.S. Army Corps of Engineers St. Louis District

Prepared for
Army Environmental Center (AEC)
and
Fort Detrick, US. Army Garrison

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EXECUTIVE SUMMARY

Recent public concerns regarding the use and testing of Agent Orange at Fort Detrick in the past resulted in the Army Environmental Center (AEC) and the Fort Detrick U.S. Army Garrison requesting an Archives Search Report (ASR) to document the use and testing of **2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)** and its family of agents at Fort Detrick along with other activities at the installation.

Work at Fort (nee Camp) Detrick with military herbicides began during World War II. In April 1944, the Chemical Warfare Service (CWS) gave the Plant Research Branch at Detrick the mission of developing chemical agents to destroy or reduce the value of crops. These "Chemical Plant Growth Regulators" or inhibitors were studied under the code letters "LN". Initial work at Camp Detrick involved a series of screening tests in the lab involving seeds, a few plants and minute quantities of 1,058 synthetic organic compounds to determine the ones best suited for military purposes. They determined that the halogenated phenoxy acetic acids appeared to be the best suited and began studying selected LN agents more thoroughly. Of the compounds tested, agent LN-8, 2,4-Dichlorophenoxyacetic acid (2,4-D) proved the most effective against a wide variety of crops and was used as the common reference material in the plant growth regulating tests. Another promising compound was LN-14, 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T). Later, a 50/50 mix of the n-butyl ester of 2,4-D, also known as (a.k.a.) LN-143 and the n-butyl ester of 2,4,5-T, (a.k.a. LN-974) became the military defoliant or herbicide Agent Orange (Agent LNX). By the late 1960s, it became known that the manufacture of 2,4,5-T was contaminated with a 2,3,7,8-tetrachlorodibenzodioxin (TCDD), a dioxin and that TCDD that was the main cause of adverse health effects from the use of Agent Orange.

The 2,4,5-T compounds and variations of them tested at Detrick throughout the war and in the subsequent peace time included:

- LN-14 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
- LN-14 (TEA) Triethanolamine 2,4,5-Trichlorophenoxyacetate
- LN-379 Chloride of LN-14
- LN-690 Undetermined derivative of LN-14
- LN-698 Undetermined derivative of LN-14
- LN-722 Undetermined derivative of LN-14
- LN-835 Undetermined derivative of LN-14
- LN-852 Tria-(hydroxymethyl) methyl amide of LN-14
- LN-951 pentachlorophenyl 2,4,5-Trichlorophenoxyacetate
- LN-974 butyl 2,4,5-Trichlorophenoxyacetate
- LN-982 Undetermined derivative of LN-14
- LN-986 ethyl 2,4,5-Trichlorophenoxyacetatte
- LN-1784 α-(2,4,5-Trichlorophenoxy)-butyric acid
- LN-1856 a-(2,4,5-Trichlorophenoxy)-propionic acid
- LN-2426 2,4,5-Trichlorophenoxyacetic anhydride

- LN-2777 isopropyl 2,4,5-Trichlorophenoxyacetate
- LN-2813 2-(2',4',5-Trichlorophenoxy)-ethyl 2",4"-Dichlorophenoxyacetate
- LN-3005 γ-(2,4,5-Trichlorophenoxy)-butyric acid
- LN-? 2,4-dichlorophenyl 2,4,5-Trichlorophenoxyacetic acid
- LN-? 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid

The "C" Division (or later the Crops Division) of the Chemical Corps Biological Laboratories at Camp Detrick conducted field plot experiments with plant inhibitors from 1944 through 1951 and published the results of this field work on a generally annual basis in a series of Special Reports, specifically Nos. 79, 92, 105, 130, 153 and 156. The primary objectives of the tests were to ascertain the most effective agent for causing yield reductions for various crops; the best methods of application and to determine the effects during different stages of development on plant growth.

The described field trials were not large scale tests but were smaller efforts involving test plots typically 6 by 18 feet in size, with the agent being tested applied with handheld sprayers. To prevent drift of spray, a movable light metal framed shelter with wind resistant cloth was used. The test locations were identified as Fields A, B, C, D, E and F with three additional locations of plowed and unplowed grasses also used (Locations A, Location B and "the area to the northwest of Field B"). The specific boundaries on Fort Detrick of these fields are not confirmed with the material gathered to date but it appears that all fields are on the current Fort Detrick Area A, except for Field B, which is in Area B. Probable locations for Fields C and D have been identified within Area A.

Although the purpose of Special Reports was not to report on the amounts of agents used, the amounts can generally be calculated based on the information provided. The total amount of the 2,4,5-T compounds used for the years are approximated as:

- 911.92 grams plus an estimated additional 1,500 grams – 1944-45
- 2,620.17 grams – 1946-47
- 1,544.72 grams – 1948
- 76.18 grams – 1949
- 399.18 grams – 1950
- 460.87 grams – 1950-51

Two subsequent field trials are known to have occurred at Fort Detrick. On 28 July 1953, a series of anti-crop field tests using a truck mounted experimental spray tower occurred on test plots in Area B (specific location not stated). The estimated amount of agent LN-974 used was approximately 106.29 grams. In 1968, Fort Detrick investigated the lateral and vertical movement of four herbicides through soil, including Agent Orange on 20 by 20-foot test plots. The amount of 2,4,5-T agent LN-974 released for this experiment was approximately 11.99 grams. As before, the specific location of these tests on Fort Detrick is not confirmed. An evaluation of the amounts of 2,4,5-T compounds reportedly spray-tested in the greenhouse to evaluate them as effective defoliants, and herbicides

from August 1961 to June 1963 at Fort Detrick has not occurred as of yet as the report is classified and has not been available for review yet.

There is currently no known documentation to indicate large scale dissemination tests of LN agents involving aerial spraying occurred at Fort Detrick. Fort Detrick personnel did conduct or participate in such larger scale dissemination tests as early as World War II but these field tests occurred at other locations, such as Bushnell or Eglin Air Force Base, FL, the Granite Peak Installation of Dugway Proving Ground, UT, Terre Haute, IN and Beaumont, TX.

This brings the total amount of 2,4,5-T compounds known to have been used at Fort Detrick is **approximately 6,131.32 grams with another 1,500 grams estimated to have been used in 1944-45. Therefore, a total estimate would be on the order of 7.63 Kilograms (Kg) or 16.82 pounds**. In comparison, the U.S. Department of Agriculture reported the farm use rates in 1969 averaged from .24 to 2 lbs per acres with a total farm use average of 0.48 lbs per acres (ex.: 100 acres farm would use 48 lbs in one year).

This preliminary ASR does not represent a comprehensive research effort regarding the subject topic or property. In the coming weeks and months, additional relevant reports that have not been acquired to date will provide more data. Research in the coming months regarding additional historical textual, cartographic and aerial images, should provide a clearer picture regarding likely and specific locations of 2,4,5-T use at Fort Detrick.

1 INTRODUCTION

1.1 Fort Detrick ASR Background

On 18 August 2010, the Army Environmental Center (AEC) tasked the Ordnance and Technical Services Branch of the St. Louis District of the U.S. Army Corps of Engineers (CEMVS-EC-P) to provide research and analysis assistance regarding Fort Detrick, which will be documented in an Archives Search Report (ASR). This report represents CEMVS-EC-P Preliminary Findings regarding the use and testing of **2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)** at Fort Detrick based on historical documents located to date. While it is still early in the multi-month ASR research process, the research team expedited locating field test reports regarding 2,4,5-T. The documents found to date may not be comprehensive of all the material potentially available and these finding may be augmented with documents located through the additional comprehensive archival research planned to be completed in the coming months.

1.2 2,4,5-Trichlorophenoxyacetic Acid (2,4,5-T) Background

The tactical military herbicide Agent Orange (Agent LNX) consists of a 50/50 mix of n-butyl ester of **2,4-Dichlorophenoxyacetic acid** (2,4-D) [also known as (a.k.a.) LN-143] and n-butyl ester of **2,4,5-Trichlorophenoxyacetic acid** (2,4,5-T), [a.k.a. LN-974]. It is a dark oily liquid that is insoluble in water but soluble in fuel oil, kerosene and similar solvents. Similarly Agent Purple is a mix of 50% n-butyl ester of 2,4-D (LN-143), 30% n-butyl ester of 2,4,5-T (LN-974) and 20% iso-butyl ester 2,4,5-T[1]. By the late 1960s, it became known that the manufacture of 2,4,5-T was contaminated with a 2,3,7,8-tetrachlorodibenzodioxin (TCDD), a dioxin and that TCDD was the main cause of adverse health effects from the use of Agent Orange and Agent Purple. In 1940s and 1950s, the code names for 2,4,5-T and its family of agents included:

- LN-14 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
- LN-14 (TEA) Triethanolamine 2,4,5-Trichlorophenoxyacetate
- LN-379 Chloride of LN-14
- LN-690 Undetermined derivative of LN-14
- LN-698 Undetermined derivative of LN-14
- LN-722 Undetermined derivative of LN-14
- LN-835 Undetermined derivative of LN-14
- LN-852 Tria-(hydroxymethyl) methyl amide of LN-14
- LN-951 pentachlorophenyl 2,4,5-Trichlorophenoxyacetate
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- LN-982 Undetermined derivative of LN-14
- LN-986 ethyl 2,4,5-Trichlorophenoxyacetatte[2]
- LN-1784 α-(2,4,5-Trichlorophenoxy)-butyric acid[3]
- LN-1856 a-(2,4,5-Trichlorophenoxy)-propionic acid[4]

- LN-2426 2,4,5-Trichlorophenoxyacetic anhydride
- LN-2777 isopropyl 2,4,5-Trichlorophenoxyacetate
- LN-2813 2-(2',4',5-Trichlorophenoxy)-ethyl 2",4"-Dichlorophenoxyacetate[5]
- LN-3005 γ-(2,4,5-Trichlorophenoxy)-butyric acid[6]
- LN-? 2,4-dichlorophenyl 2,4,5-Trichlorophenoxyacetic acid
- LN-? 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid

1.3 Previous Summary Reports Regarding Agent Orange Herbicides at Camp/Fort Detrick

1.3.1 General

The Department of Defense (DoD) has prepared summary reports regarding the use of Agent Orange that include information about testing involving Camp Detrick. The following paragraphs discuss the information released in these documents.

1.3.2 Joint CB Data Source Book Volume VII Anti-plant Agents Part One: Agent LNX – December 1971

The report summarizes the findings from field and laboratory test data for the herbicide LNX or Agent Orange, including large scale aerial and ground dispensers used for LNX dissemination. Appendix A noted that in mid-1963, Fort Detrick conducted field trials regarding calibration trials for C-123/MC-1 Spray Systems as reported in TR [Technical Report]-46, June 1964.[7] Review of TR-46 indicates that while the U.S. Army Biological Laboratories Fort Detrick oversaw the work, the tests occurred at Eglin Air Force Base in Florida.[8]

1.3.3 U.S. Army Activities in the U.S. Biological Warfare Programs, 1942-1977, February 1977

This public accounting or review of the US Biological Weapons (BW) program noted that Fort Detrick conducted anti-crop research with BW agents as well as chemical herbicides and defoliants. These were not included in the 1977 BW accounting as they were not part of the BW microbial program.[9]

1.3.4 DUSD(I&E) Herbicide and Agent Orange Response to Congressman Evans – 23 September 2003

On 23 September 2003, Principal Assistant Deputy Under Secretary of Defense (Installations and Environment) (DUSD(I&E)) responded to a request by Congressman Lane Evans regarding use, storage and testing of herbicides including Agent Orange, resulted in summary information regarding such activities by the DoD being presented to the Congressman and the Department of Veterans Affairs. This is the source of the

information included in the Department of Veterans Affairs web site "Agent Orange: Herbicide Tests and Storage in the U.S.": http://www.publichealth.va.gov/exposures/agentorange/outside_vietnam_usa.asp. That study noted the following reports relating to Camp (Fort) Detrick:[10]

- Special Report No. 92, Field Plot Experiments with Plant Inhibitors 1946 and 1947 Seasons, Camp Detrick, MD-Fields A, B, and C; Herbicides: 2,4,5-T, 2,4,5-T triethanolamine, tributylphosphate, ethyl 2,4-D, butyl 2,4,5-Ttriet 2,4-D,

The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays to crops or to the soil in the solid form to be taken up by the roots.

- Special Report No. 105, Field Plot Experiments with Plant Inhibitors 1948 Season Camp Detrick, MD-Fields C, D, and E; Herbicides: 2,4,5-T, isopropyl phenol carbamate, LN-2426, 2,4-D

The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays to crops or to the soil in the solid form to be taken up by the roots.

- Special Report No. 130, Field Plot Experiments with Plant Inhibitors 1949 Season Camp Detrick, MD-Fields C, D and E; Herbicides: triethelyne. 2,4,5-T, carbamates

The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays to crops or to the soil in the solid form to be taken up by the roots.

- Special Report No. 153, Field Plot Experiments with Plant Inhibitors, 1950 Season Camp Detrick, MD-Fields A, B, D and E; Herbicides 2464, butyl 2,4-D, 974, butyl 2,4,5-T, q:q 143 and 974

The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays to crops or to the soil in the solid form to be taken up by the roots.

- Special Report No. 156, Field Plot Experiments with Plant Inhibitors, 1950-51 Season Camp Detrick, MD-Field F; Herbicides 2464, carbamate, butyl 2,4-D, 143 and 974, 2,4,5-T, 2,4-D, Orange

The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays to crops or to the soil in the solid form to be taken up by the roots.

- Abstracts of Technical Publications April 1965-June 1965, July 1965, Technical Report 50, Defoliation Studies: Screening of Defoliants, Herbicides, and Desiccants Fort Detrick, MD; Herbicides: 1410 compounds

From 8/1961 to 6/1963, compounds were spray-tested in the greenhouse to evaluate them as effective defoliants, and herbicides.

- Special Report No. 201, Field Development of Chemical Anticrop Agents, Response of Field Grown Crops to Chemical Anticrop Agents Released from Experimental Spray tower Area B, Camp Detrick, MD; Herbicides3:1 mixture 2,4-D and 2,4,5-T

2 REPORTS RELATING TO 2,4,5-T USE AND TESTING AT CAMP/FORT DETRICK

2.1 History of the CWS in WWII. Vol. 2 - Biological Warfare Research in the United States – November 1947[11]

This massive historical report summarizes the United States BW efforts during World War II, detailing the organizations and operations used in those efforts including Camp Detrick, the center of BW efforts during the war and afterwards. Of particular interest to this study is Chapter XXIII, Plant Growth Regulators. In April 1944 during WWII, the Chemical Warfare Service (CWS) gave the Plant Research Branch at Camp Detrick the mission of developing chemical agents to destroy or reduce the value of crops. These Chemical Plant Growth Regulators or inhibitors were studied under the code letters "LN". The U.S. Department of Agriculture (USDA) at Beltsville, MD and Ohio State University undertook related efforts. Camp Detrick examined and tested a total of 1,058 chemical compounds, with all but 226 of the compounds being prepared at Camp Detrick. The initial screening tests consisted of a series of lab and greenhouse tests involving seeds, a few plants and minute quantities of the synthetic organic compounds to determine the compounds best suited for military purposes. They determined that the halogenated phenoxy acetic acids appeared to be the best and of the compounds tested, only a few were studied at any length including:

LN-8	2,4-Dichlorophenoxyacetic acid (2,4-D)
LN-14	2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
LN-379	Chloride of LN-14[12]

Of the compounds tested, 2,4-D proved the most effective against a wide variety of crops and was used as the common reference material in the plant growth regulating tests. 2,4-D was also produced in bulk for the CWS under contract (Dow Chemical Corporation and Sherwin-Williams Company). The bulk form of LN-8 came in three forms:

VKA	acid solid or granular form of LN-8
VKL	liquid LN-8 in tributyl phosphate and oil
VKS	ammonium salt of LN-8

This report also includes Chapter XXIV, Chemical Defoliants which describes the activities by C Division in determining chemical agents for use in "marking, defoliating or increasing the flammability of forest vegetation", determining that ammonium thiocyanate and zinc chloride were the best. The scope of this work during WWII was limited in nature and does not include the LN agents, which would be used as defoliants in the decades that followed. Field trials of the WWII era defoliants occurred at several locations in Florida.

2.2 Special Report No. 79, Crop Destruction By Chemical Agents - 1947[13]

2.2.1 Estimated Amount of 2,4,5-T Agents Used in 1944-45

The total amount of **2,4,5-T compounds known to have been used for the 1944-45 Field plots tests is approximately 911.92 grams but another approximately 1,500 grams was also estimated to have been used**.

The following sub-paragraphs summarize the 1944 through 1945 field plot tests in general and specifically those that deal with 2,4,5-T and its variants.

2.2.2 Overview of Special Report No. 79

Completion of Special Report No. 79 occurred after August 1947 when the WWII history discussed above was being written[14], however the report summarizes "C" Division of Camp Detrick efforts regarding Chemical Plant Growth Regulators, code letter LN, between April 1944 and August 1946 as noted in that report. This work was in coordination of other efforts previously started by the allies, the USDA at Beltsville, MD and Ohio State University. With completion of the laboratory and greenhouse facilities at Camp Detrick in July 1944, work expanded there rapidly. Small plot experiments at Fort Detrick commenced in June 1944. This required extensive studies to determine the proper agent to use for specific crops, the amount required, the most effective and easiest method of application and the most susceptible stage of the plant development for application.

2.2.3 Screening LN Agents

The chemical compounds investigated as LN agents were synthetic organic (i.e. man-made carbon-based) compounds as opposed to inorganic (non-carbon based) or organic (carbon based) compounds of typical conventional herbicides of the period, which required relatively high concentrations to be used. Preliminary work involved screening of these organic compounds as potential LN agents for their inhibitory responses in plants. The screening involved a battery of tests of each chemical compound comparing their effectiveness against agent LN-8 in the same test. The LN-8 results were designated as 100% standard with other agents scoring above or below this standard. For example, the Corn Germination Test involved the treatment of corn seeds with solutions of 1 or 10 parts per million (ppm) of the potential LN agent to be tested, and subsequent measurement of the effect of this agent on elongation of the primary root. The test involved 25 seeds per dish, with three dishes run per agent. Other tests were the Kidney Bean Single Droplet Test, the Kidney Bean Spray Test, Kidney Bean Soil Test, the Barley Soil Test, and the Rice Irrigation Water Test. In all, approximately 1,060 compounds were screened for activity as LN agents. Of these, approximately 336 were not sufficiently water-soluble to be tested by either the corn germination or rice irrigation

methods. Approximately 223 were oil-insoluble and could not be checked by the oil single droplet method on kidney bean plants, even with the use of a co-solvent.

The primary screening procedures established the relative inhibitory effectiveness of the LN agents in terms of LN-8. The rates used; however, were of an order which would be ineffective on well established plants since the plants and stages of development utilized in the screening tests were those which responded most readily to very low concentrations of agents. Therefore, tt was necessary to develop and perfect methods of application which would permit a more critical evaluation of LN agents when used in amounts which would cause death or severe inhibition to a variety of crops at all stages of development and would be practical for relatively large scale green house and small scale field tests.

The primary screening for additional potential chemical plant growth inhibitors continued through at least 1950, by which point over three thousand potential LN agents had been screened.[15]

2.2.4 Contract Applications - Spraying

Developing and investigating the means to disperse the LN, required a number of trials on spraying and dusting for contact (leaf) applications, as well as additional tests for soil irrigation contamination methods. Development issues with spray apparatus included determining concentrations required, droplet size, diluent media and amount, etc. The reported tests of the various LN agents at Camp Detrick were conducted on potted plants and on small field plots with the spraying of individual plants or rows of plants primarily by hand. Eventually these methods would be translated into military applications such as using the M10 airplane smoke tanks for agent spraying in large scale trials. Dissemination and larger scale field testing of the selected LN agents (and the VK varieties) occurred at other locations than Detrick, such as Bushnell, FL, the Granite Peak Installation of Dugway Proving Ground, UT, Terre Haute, IN and Beaumont, TX and are detailed in Special Reports Nos. 12, 14, 25, 64 and 78.[i]

The dilutent media or carrier used for the solution of the LN is an important factor effecting agent delivery. Since many of the LN compounds are not readily soluble in water, various other carriers and solvents, such as lanoline, oils, or dilute aqueous solutions of ethyl alcohol have been used to facilitate their application and possibly increase their effectiveness. Tributylphosphate was found to be a good solvent for agents LN-8, LN-14, LN-32 and LN-33. Irish potatoes when sprayed at the bud stage produced

[i] The corporate author of these reports was the Special Projects Division, CWS, which included Camp Detrick personnel. Although Detrick personnel participated, and in some instances conducted these field trials. This arrangement would continue as the WWII era Special Project Division became the "Biological Department, Chemical Corps" and later the "Chemical Corps Biological Laboratories, Camp Detrick". In other words, just because Detrick personnel are writing the reports, the testing did not necessarily occur at Fort Detrick. When tests did not occur at Fort Detrick, they are outside the scope of this investigation

significantly lower yields of tubers when sprayed with LN-14 in an oil-tributylphosphate carrier at a rate of 1 pound per acre that potatoes sprayed at a comparable agent rate with an aqueous carrier. Although not specified in this document, it is assumed that multiple tests were conducted with each agent being considered at this stage of program development in various carrier solutions or media.

Among the compilation of tests published in Special Report No. 79, there are a few relating to 2,4,5-T agents. Numerous tests relating to other non-2,4,5-T related LN agents are included in Special Report No. 79 but are not discussed in this Preliminary ASR as they are outside the subject scope of 2,4,5-T agents.

According to Special Report No. 79, in one test, Detrick conducted an experiment on several 9 by 12-foot test plots of Irish potatoes (the specific plot locations was not provided). LN-14 in a three different volumes rates: 5, 10, and 20 milliliters (ml) per square yard (SY) and at three different agent concentration rates (0.5, 1.0 and 5 pounds per acre) were compared plus one control plot with no agent use, with quadruplicates (i.e. four replicates) of all the tests. This implies a total of forty 9 by 12-foot test plots, thirty-six with agent sprayed on them. Results of this testing and in general all the small scale plot testing are expressed in crops yield, in this case potatoes tubers per acre. Given this information, **approximately 87.72 grams**[ii] **of LN-14 were used for this test.** The test location is undetermined.

2.2.5 Soil Contamination – Field Investigations

Another avenue for testing of LN agents involved soil contamination. Because of the relatively large root systems of most plants and their great absorbing powers, it seemed feasible that plants could similarly be injured by the application of inhibitory agents to the soil.

Camp Detrick conducted an experiment to compare the persistence of agents LN-8 and LN-14 in soil by applying granular forms of the agent in 3, 10, and 20 pounds per acre rates[iii] on the Irish Potato plots, disking the plots and then replanting them with soybeans. Other details regarding the tests are not stated, such as the plot size and if it included replicates, though presumably they remained the same with 9 by 12-foot test plots and quadruplicate (i.e. four replicates) of all the tests. Given these assumption, **approximately445.35 grams of LN-14 used for this test.** The test location is undetermined.

[ii] The purpose of Special Reports is not to report on the total amounts of agents used and as such it is not clearly stated. Appendix A of this report includes an sample calculation of the amount used for one test, with similar methods used for subsequent tests.

[iii] The rates of agent used in soil contamination test are significantly higher for these tests and for similar testing in subsequent years.

2.2.6 Plant Responses – Agent-Crop Specificity

Camp Detrick also conducted test on LN agents applied in solution to seeds germinating on moist filter paper and in soil in an effort to determine the effectiveness of LN treatment at this stage in the plant life cycle. Although the location is not given, it is assumed to have occurred in the greenhouse. In an attempt to determine whether different LN agents had specific effects on the germination of seeds, solution of approximately 40 agents (to include LN-14) were added to soil in pots at a rate of 5 mg (0.005 grams) per 4-inch pot prior to planting seeds of 17 different broadleaf and cereal crops.

Another series of tests involved LN-8, LN-14, and LN-33 both as single agents and in various combinations of agents. These tests were conducted using plants in 4-inch pots with dosages of 6 and 3 milligrams (mg) or rather 0.006 and 0.003 grams, per pot of oats (40 plants) and of soybeans (12 plants). LN-14 caused significantly greater inhibition of germination and early development than LN-8 or LN-33 applied at equal rates. LN-33 had almost no effect on soybeans. Though no mixture was superior to an equal quantity of LN-14 alone, LN-14/LN-8 mixtures were highly inhibitory and were superior to any other combination of the three agents. This test involved a control pot and 52 plant pots for both the 6 mg per pot and of pure LN-14, four series of two agent mixtures (assumed to be 50/50 mixtures) of LN-14 and another LN agent and two test series of all three LN agents mixture (assumed to be in equal thirds). The **total LN-14 used in this series of tests is 1.10 grams**

2.2.7 Crop Susceptibility

Camp Detrick conducted a series of tests designed to evaluate the relative effectiveness of LN agents in aqueous solutions verses oil solutions against nine crops (i.e. soybeans, tomatoes, sweet potatoes, sugar beets, Irish white potatoes, rice, oats, winter rye, and corn). Completed test data regarding number of tests, rate or amount of agent used, test size (pot versus field plot) is not stated in this published report, therefore, it is not possible to compute the amount of agents used. The following table summarizes known data on these tests.

Table 2.2.7 – 1944-45 Crop Susceptibility Tests Summary			
Crop	**Agent**	**Dosage**	**Remarks**
Soybeans (Spray)	LN-14 (Water)	0.0025 grams/Square Yard (SY)	Test in Greenhouse
	LN-14 (oil)	0.0025 grams/SY	Test in Greenhouse
	LN-951	0.0025 grams /SY	Test in Greenhouse
	LN-974	0.0025 grams /SY	Test in Greenhouse
	LN-44 + LN-379	0.0025 grams /SY	Test in Greenhouse
	LN-44 + LN-835	0.0025 grams /SY	Test in Greenhouse
Soybeans (Soil)	LN-14	0.003 grams per 4-inch pot	Four replicates; ~**0.12 gram used**
	LN-690	0.003 grams per 4-inch pot	Four replicates; ~**0.12 gram used**
	LN-698	0.003 grams per 4-inch pot	Four replicates; ~**0.12 gram used**
Tomatoes (Spray)	LN-14	0.1 lb and 1.0 lb per acre (or 0.009 and 0.094 grams/SY)	At 8 to 12 inches, early flowering, and at early fruiting; on 12 by 12-foot plot; if four replicates, ~**6.60 gram used**
Tomatoes (Soil)	LN-14	4 lb per acre (or 0.375 grams/SY)	
Sweet Potatoes (Spray)	LN-14	1.0 lb and 0.2 lb per acre (or 0.094 and 0.019 grams/SY)	
	LN-14 (water)	0.1 lb per acre (or 0.009 grams/SY)	
	LN-14 (oil)	0.1 lb per acre (or 0.009 grams/SY)	
Sweet Potatoes (Soil)	LN-14	3, 10, and 20 lb per acre (or 0.281, 0.937 and 1.874 grams/SY)	Four replicates. Applied at early runner and at late runner stages; on 15 by 18-foot test plot; ~**371.12 gram used**
Sugar Beets (Spray)	LN-14	0.1, 0.05, and 0.01 lb per acre(or 0.009 0.005 and 0.001 grams/SY)	Four replicates
Sugar Beets (Soil)	Mix LN8,14, & 33	3, 10, & 20 lbs per acre (or 0.281, 0.937 and 1.874 grams/SY)	

Table 2.2.7 – 1944-45 Crop Susceptibility Tests Summary			
Crop	**Agent**	**Dosage**	**Remarks**
Irish potatoes (Spray)	LN-14 (water)	0.1 grams/SY	
	LN-14 (oil)	0.1 grams/SY	12 inch high plants
	LN-379	0.1 grams/SY	12 inch high plants
	LN-14 (water)	0.1 grams/SY	8-10 inch high plants
	LN-14 (oil)	0.1 grams/SY	8-10 inch high plant
Irish potatoes (Soil)	LN-14	4, 12, & 20 lb per acre (or 0.375, 01.125. 1.874 and 3.749 grams/SY)	6-inch pots
	LN-14	4, 12, 20, & 40 lb per acre(or 0.375, 01.125. 1.874 and 3.749 grams/SY)	
	Mixture LN-8 & 14	4, 12, 20, & 40 lb per acre(or 0.375, 01.125. 1.874 and 3.749 grams/SY)	
Rice (Water)	Mixture LN-44 & 379	0.250 grams/SY	
	Mixture LN-44, 33, & 379	0.250 grams/SY	
	Mixture LN-44, 33, & 835	0.250 grams/SY	
Rice (Spray)	Mixture LN-44, 33, &379	7.5 lb per acre	
Oats (Spray)	LN-14	0.100 grams/SY	
	LN-379	0.100 grams/SY	
	LN-379 + 1% DCH	0.100 grams/SY	
	LN-379 + 3% DCH	0.100 grams/SY	
	LN-14	0.200 grams/SY	Plants 6 inches tall
	LN-690	0.200 grams/SY	Plants 6 inches tall
	LN-698	0.200 grams/SY	Plants 6 inches tall

Table 2.2.7 – 1944-45 Crop Susceptibility Tests Summary			
Crop	**Agent**	**Dosage**	**Remarks**
Oats (Soil)	LN-14	10ml per 4-inch pot	
	LN-690	10ml per 4-inch pot	
	LN-698	10ml per 4-inch pot	
	Mixture LN-8, 14, 33	0.0015 and 0.003 grams per 4-inch pot	
Corn (Spray)	LN-14	2 and 10 lbs per acre (or 0.187 and 0.937 grams/SY)	Sprayed at 4-5", 18-24" and pre-tassel 40-50"

Without additional information, it is not possible to calculate a total amount of 2,4,5-T compounds used for these tests. However, **the total for the tests that can be calculated is approximately 377.76 grams.** This roughly estimated to be about one fifth of the total based on what is known about the other tests. In other words, **another approximately 1,500 grams was used**.

2.3 Special Report No. 92, Field Plot Experiments with Plant Inhibitors 1946 and 1947 Seasons – 24 February 1948[16]

2.3.1 Estimated Amount of 2,4,5-T Agents Used in 1946-47

The total amount of **2,4,5-T compounds used for the 1946-47 Field plots tests is approximately 2,620.17 grams with another estimated 140.58 grams.** This includes:

- 2,134.35 grams LN-14 (2,4,5-Trichlorophenoxyacetic acid (2,4,5-T))
  - ~222.14 grams in Field A
  - ~27.78 grams in Field B
  - ~1,838.43 grams in Field C
  - ~45.99 grams "area to the northwest of Field B"
- ~337.25 grams LN-14 (TEA) (Triethanolamine 2,4,5-Trichlorophenoxyacetate)
  - ~194.67 grams in Field A
  - ~142.58 grams in Field C
- ~337.08 grams LN-951 (pentachlorophenyl 2,4,5-Trichlorophenoxyacetate) in Field C
- 49.12 grams LN-974 (butyl 2,4,5-Trichlorophenoxyacetate)
  - ~40.67 grams in Field A
  - ~8.45 grams in Field C
- 5 grams 2,4-dichlorophenyl 2,4,5-Trichlorophenoxyacetic acid in Field C

- ~19.69 grams 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid
  - ~9.69 grams in Field A
  - ~10.00 grams in Field C

Alternately this breaks out as approximately the following amounts in the following areas:

- ~467.48 grams in Field A
- ~27.78 grams in Field B
- ~2,219.49 grams in Field C
- ~45.99 grams "area to the northwest of Field B"

The following sub-paragraphs summarize the 1946 through 1947 field plot tests in general and specifically those that deal with 2,4,5-T and its variants.

2.3.2 Overview of Special Report No. 92

In 1946-47, C Division of Camp Detrick continued conducting field plot experiments with plant inhibitors. The experiments were an extension of the previous field work published in Special Report Nos. 79 described above and conducted in 1944 through 1945. The development of plant inhibitors is described as occurring in three phases. Phase one involves evaluating and selecting potential agents in laboratory and greenhouse studies. The second phase consists of small field plot experiments with the most promising compounds and the third phase consisting of larger scale field trials with operational munitions or equipment. Special Report No. 92 summarized the field plot experiments completed in 1946 and 1947 seasons.

The tests occurred in three locations: Fields A, B and C. Field A consisted of approximately 2 acres of Frankstown silt loam soil "located within the restricted areas and is 100 yards north of the C Division building". The soil classifications delimitation is based on the 1919 Soil Survey of Frederick County, Maryland (see Figure 1). This building number and location have not been determined yet, but the open area of the WWII era "Restricted Area" can be seen on the cantonment area map (see Figure 2 on next page). This was one of the first fields used for small plot experiments and was in use in 1946 and 1947. Field B consisted of approximately 3 acres of Athol gravelly loam soil "located near the northeastern corner of the Grid area". It was one of the first three fields used for small plot experiments and was in use in 1946 and 1947.[17] Field C consisted of approximately 5 acres of Frankstown silt loam soil "located north of the coal trestle on the railroad". This was one of the first three fields used for small plot experiments and was first used in 1946 and 1947.[18] A probable location for the railroad coal trestle and hence, Field C can be seen on Figure 2.

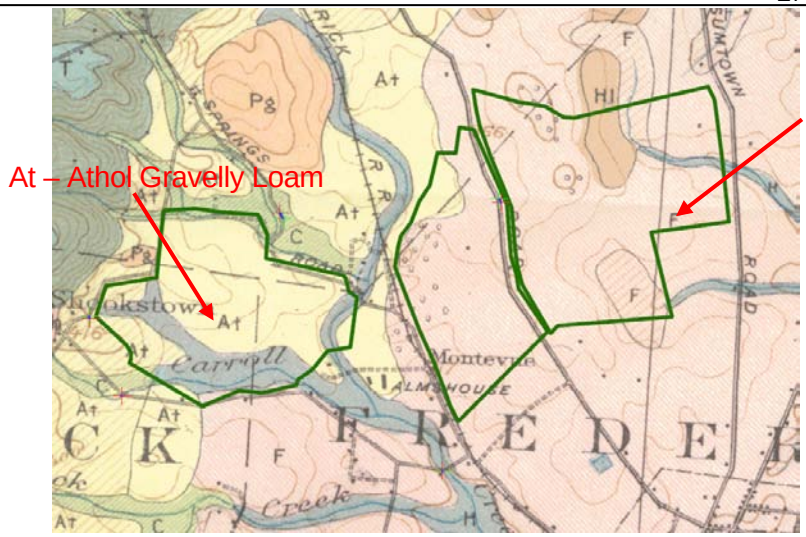

Figure 1 *–Excerpt of 1919 Soil Survey of Frederick County, MD 1919 with Fort Detrick Boundaries*[19]

Note: 1919 soil classifications do not directly correlate to the current ones included on the USDA Natural Resources Conservation Service Soil Survey classifications.[20]

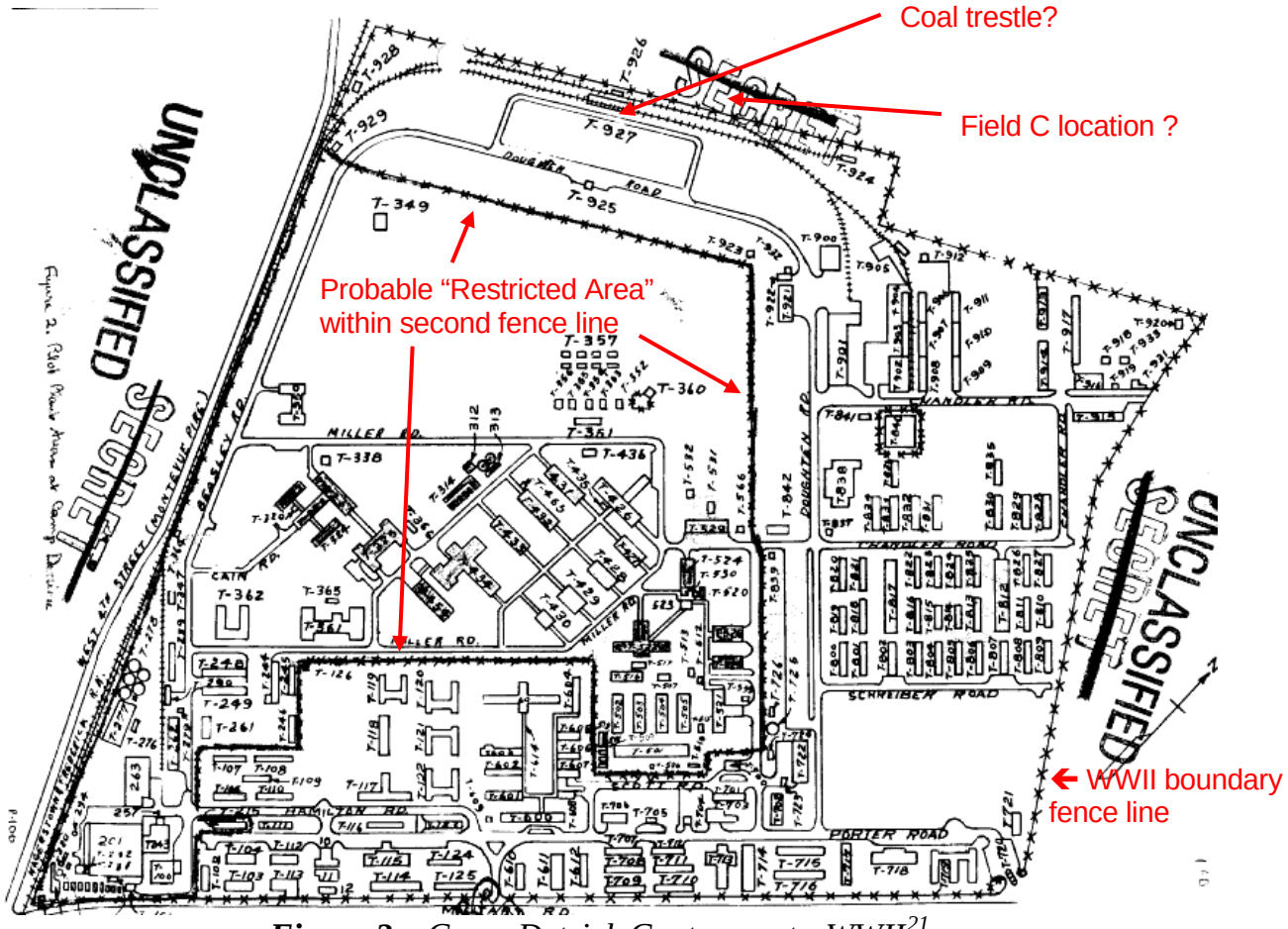

Figure 2 – *Camp Detrick Cantonment - WWII*[21]

NOTE: portion of WWII-era cantonment included on the southwestern fifth most portion of the current Fort Detrick Area A.

The equipment used to apply the agent was handheld sprayers, specifically an atomizer spray gun or a DeVilbiss types MBC spray gun, which was used in all the 1947 experiments. In 1946, a 4 by 5-foot cloth covered shield was used to prevent drift of spray to adjacent plots. In 1947, a special movable light metal framed chamber 5 feet in height with wind resistant cloth was used (see Figure 3).

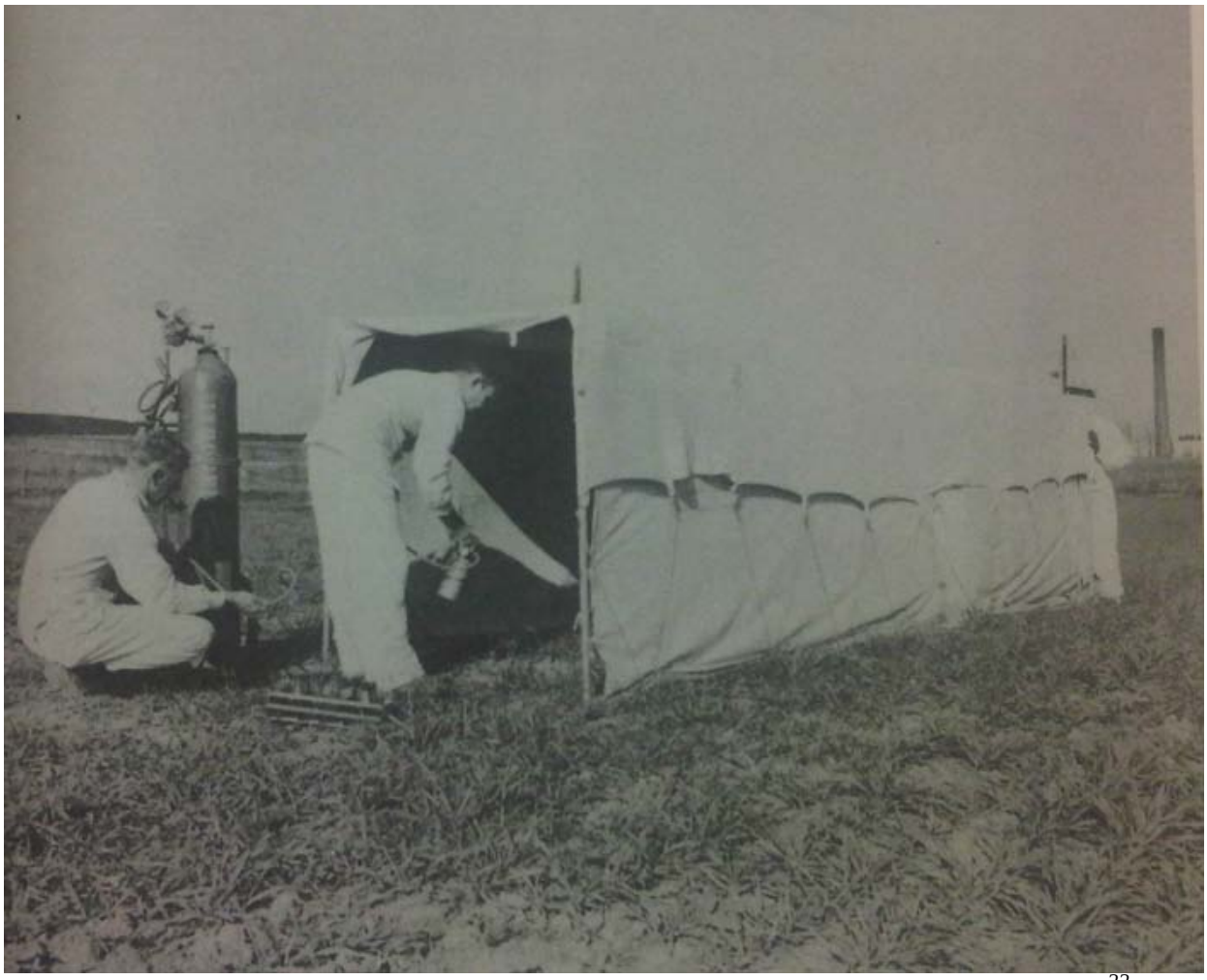

Figure 3 – *Spray chamber used around plots when making spray treatments*[22]
Note: DeVilbiss types MBC spray gun

2.3.3 Volume-Concentration Spray Studies, 1946 Experiment 1

Camp Detrick conducted this experiment on 12 by 15-foot (i.e. 180 SF or 20 SY) test plots of Irish potatoes in Field A to test volume of spray on growth inhibiting qualities of LN-14 and LN-14 (TEA) (Triethanolamine 2,4,5-Trichlorophenoxyacetate) in a concentrations of 0.1 and 0.5 grams per square yard and at three different spray volumes, with four replicates of these tests against control plots. Given this information, **approximately 144 grams of LN-14 and approximately 144 grams of LN-14 TEA were used for this test.**

Figure 4 – *Irish potatoes 26 days after spraying with* LN-14 (TEA*) – 24 June 1946*[23]

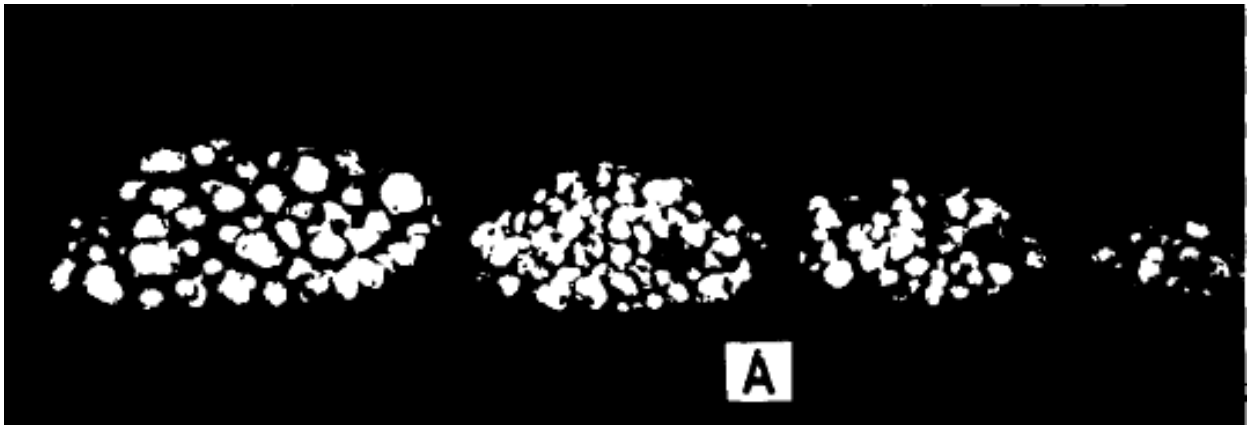

Figure 5 – *Comparison of relative effects of LN-14 in aqueous spray on tubers when applied a constant rate of 0.1 grams/SY but at different volumes - 1946*[24]
From Left to right: untreated, 5, 10 and 20 ml/SY respectively.

2.3.4 Volume-Concentration Spray Studies, 1946 Experiment 2

Camp Detrick conducted this experiment on 6 by 10-foot (i.e. 60 SF or 6.7 SY) test plots of soybeans in Field A to test a different s spray gun on growth inhibiting qualities of LN-14 (TEA) in a concentrations of 0.1 and 0.025 grams per square yard and at three different spray volumes, with four replicates of these tests against control plots. Given this information, **approximately 10 grams of LN-14 TEA were used for this test.**

2.3.5 Volume-Concentration Spray Studies, 1947 Experiment 1

Camp Detrick conducted this experiment on 6 by 18-foot (i.e. 108 SF or 12 SY) test plots of soybeans in Field C to test volume of spray on growth inhibiting qualities of LN-14 and LN-14 (TEA) in a concentration of 0.008 and 0.020 grams per square yard respectively and at three different spray volumes, with four replicates of these tests against control plots. Given this information, **approximately 1.15 grams of LN-14 and approximately 2.88 grams of LN-14 TEA were used for this test.**

2.3.6 Size of Droplet Studies, 1946 Experiment 1

Camp Detrick conducted this experiment on 12 by 15-foot (i.e. 20 SY) test plots of Irish potatoes in Field A to test the effect of droplet size using LN-14 (TEA) (Triethanolamine 2,4,5-Trichlorophenoxyacetate) and butyl 2,4,5-Trichlorophenoxyacetate (LN-974) in a concentration of 0.05 and 0.2 grams per square yard respectively with two different droplet sizes, with four replicates of these tests against control plots. Given this information, **approximately 40 grams of LN-14 TEA and approximately 40 grams of LN-974 were used for this test.**

2.3.7 Size of Droplet Studies, 1946 Experiment 2

Camp Detrick conducted this experiment on 6 by 10-foot (i.e. 6.7 SY) test plots of soybeans on Field A to test the effect of droplet size using Triethanolamine 2,4,dichlorophonoxyacete and ethyl 2,4,dichlorophonoxyacete. No 2,4,5-T agents were used in this experiment.

2.3.8 Stage of Development Spray Studies, 1946 Experiment 1

Camp Detrick conducted this experiment on 5 by 10-foot (i.e. 30 SF) treated test plots of oats in Field B and used ammonium sulfate, LN-8, O-isopropyl N- Phenyl carbamate and tributyl phosphate. No 2,4,5-T agents were used in this experiment.

2.3.9 Stage of Development Spray Studies, 1947 Experiment 1

Camp Detrick conducted this experiment on 3 by 18-foot treated test plots of wheat in Field A and used O-isopropyl N- Phenyl carbamate. No 2,4,5-T agents were used in this experiment.

2.3.10 Stage of Development Spray Studies, 1947 Experiment 2

Camp Detrick conducted this experiment on 6 by 18-foot (i.e. 108 SF or 12 SY) test plots of soybeans in Field C with LN-14 and pentachlorophenyl 2,4,5-Trichlorophenoxyacetate (LN-951) in concentrations of 0.005, 0.025 and 0.050 grams per square yard respectively and at four different plant growth stages with four replicates of these tests against control plots. Given this information, **approximately 15.36 grams of LN-14 and approximately 15.36 grams of LN-951 were used for this test.**

2.3.11 Stage of Development Spray Studies, 1947 Experiment 3

Camp Detrick conducted this experiment on 7.5 by 18-foot (i.e. 135 SF or 15 SY) test plots of Sweat Potatoes in Field C with butyl 2,4,5-Trichlorophenoxyacetate (LN-974) in concentrations of 0.0025, 0.010 and 0.050 grams per square yard respectively and at two different plant growth stages with four replicates of these tests with two control groups. Given this information, **approximately 2.1 grams of LN-974 were used for this test.**

2.3.12 Plant Inhibitor Comparisons in Aqueous and Non-Aqueous Solutions, 1946 Experiment 1

Camp Detrick conducted this experiment on 6 by 10-foot (i.e. 6.67 SY) test plots of soybeans in Field A to compare the effectiveness of low volume sprays using, LN-14 (TEA) against other LN agents in a concentration of 0.025 grams per square yard, with four replicates. Given this information, **approximately 0.67 grams of LN-14 TEA were used for this test.**

2.3.13 Plant Inhibitor Comparisons in Aqueous and Non-Aqueous Solutions, 1946 Experiment 2

Camp Detrick conducted this experiment on 6 by 10-foot (i.e. 6.67 SY) test plots of soybeans in Field A to compare the effectiveness of low volume sprays using LN-14, LN-974 against other LN agents in a concentration of 0.025 grams per square yard, with four replicates. Given this information, **approximately 0.67 grams of LN-14 and approximately 0.67 grams of LN-974 were used for this test.**

2.3.14 Plant Inhibitor Comparisons in Aqueous and Non-Aqueous Solutions, 1946 Experiment 3

Camp Detrick conducted this experiment on 12 by 18-foot test plots of corn in Field B to compare the effectiveness of low volume sprays of LN agents, however no 2,4,5-T agents were used in this experiment.

2.3.15 Plant Inhibitor Comparisons in Aqueous and Non-Aqueous Solutions, 1947 Experiment 1

Camp Detrick conducted this experiment on 6 by 10-foot (i.e. 6.67 SY) test plots of soybeans in Field C to compare the effectiveness of low volume sprays using, LN-14, LN-974 and LN-951 against other LN agents in a concentrations of 0.005 and0.020 grams per square yard, with four replicates. Given this information, **approximately 1.20 grams each of LN-14, LN-974, and LN-951 were used for this test (total 3.60 grams of 2,4,5-T agents).**

2.3.16 Plant Inhibitor Comparisons in Aqueous and Non-Aqueous Solutions, 1947 Experiment 2

Camp Detrick conducted this experiment on 7.5 by 20-foot (i.e. 16.7 SY) test plots of Irish potatoes in Field C to compare the effectiveness of low volume sprays using, LN-14, LN-974, LN-951 and LN-14 TEA against a control in concentrations of 0.010 and 0.050 grams per square yard, with four replicates. Given this information, **approximately 4.0 grams each of LN-14, LN-14 TEA, LN-951, and LN-974 were used for this test (total 16 grams of 2,4,5-T agents).**

2.3.17 Plant Inhibitor Comparisons in Aqueous and Non-Aqueous Solutions, 1947 Experiment 3

Camp Detrick conducted this experiment on 6 by 18-foot (i.e. 12 SY) test plots of soybeans in Field C to compare the effectiveness of low volume sprays using LN-14 and LN-974 in two different carriers (oil emulsion and diesel oil) against LN-14 TEA in concentrations of 0.002 and0.010 grams per square yard and two controls, with four replicates. Given this information, **approximately 1.15 grams of LN-14, approximately 1.15 grams of LN-974 ,and approximately 0.58 grams of LN14-TEA were used for this test.**

2.3.18 Observational Spray Experiments, 1947 Experiment 1

Camp Detrick conducted this experiment on 3 by 18-foot test plots of wheat in Field A to compare the effectiveness of various oils in controlling vegetation. No 2,4,5-T agents were used in this experiment.

2.3.19 Observational Spray Experiments, 1947 Experiment 2

Camp Detrick conducted this experiment on 7.5 by 9-foot (i.e. 7.5 SY) test plots of Irish potatoes in Field C to compare the effectiveness of various oils in controlling vegetation versus LN-14 in a concentration of 0.1 grams per square yard on two plots with no

replicates. Given this information, **approximately 1.50 grams of LN-14 were used for this test.**

2.3.20 Observational Spray Experiments, 1947 Experiment 3

Camp Detrick conducted this experiment on 1 to 3 rows 6 feet long on a wide variety of broadleaf plants (i.e. potatoes, carrots, garden beets, bush beans, soybeans, okra, peanuts, Swiss chard, cabbage, tomatoes, peppers, and sweet potatoes) in Field C to compare the effectiveness of plant growth inhibitors. LN-14 and LN-14 (TEA) in concentrations of 0.5 and 1.0 pounds per acre respectively (or rather 0.47 and 0.094 grams per square yard) were used at two different growth stages (blossom versus well formed fruit) and a third test of LN-14 in concentrations of 1.5 pounds per acre (0.14 grams per square yard) applied on mature plants. Assuming "1-3 rows" equates to an average 4.5 feet and given that 6 feet of 12 types of vegetables were tested this equates to a 324 square feet (SF) (or rather 36 SY) per test group. No replicates plots were conducted for this test. Given this information, **approximately 8.43 grams of LN-14 and approximately 6.75 grams of LN14-TEA were used for this test.**

2.3.21 Observational Spray Experiments, 1947 Experiment 4

Camp Detrick conducted this experiment on 3 by 21-foot (i.e. 7 SY) test plots of soybeans in Field C to observe growth of progeny plants treated at sub-lethal levels using a variety of LN-agents and LN-14 (TEA) in concentration of 0.025 grams per square yard. No formative effects were noted in plants grown from the harvested seeds in 1947. Given this information, **approximately 1.8 grams of LN14-TEA were used for this test.**

2.3.22 Soil Application – Plant Inhibitor and Stage of Development Study, 1946 Experiment 1

Camp Detrick conducted this experiment on 6 by 8-foot test plots of oats in Field B with 2,4-D agents. No 2,4,5-T agents were used in this experiment.

2.3.23 Soil Application – Plant Inhibitor and Stage of Development Study, 1947 Experiment 1

Camp Detrick conducted this experiment on 6 by 18-foot (i.e. 12 SY) test plots of soybeans in Field C to compare the effectiveness of plant growth inhibitors at different plat growth stages. LN-14 and LN-951 in concentrations of 3, 6, and 12 pounds per acre (i.e. 0.28, 0.56 and 1.12 grams per square yard) were used at three different growth stages with four replicates. The LN-14 used was a commercial product by Dow Chemical, while the Chemical Branch of the B.S. Division prepared the LN-951 used. Given this information, **approximately 283.40 grams of LN-14 and approximately 283.40 grams of LN951 were used for this test.**

2.3.24 Soil Application – Plant Inhibitor Comparisons, 1947 Experiment 1

Camp Detrick conducted this experiment on 1 SY test plots of tomatoes (single plat) in Field C to study effects of 18 plant growth inhibitors applied as dusts in soil. The only 2,4,5-T product was 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid applied in concentrations of 5 and 20 pounds per acre (i.e. 0.47 and 1.87 grams per square yard) with two replicates. Given this information, **approximately 4.69 grams 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid was used for this test.**

2.3.25 Soil Application – Plant Inhibitor Comparisons, 1947 Experiment 2

Camp Detrick conducted this experiment on 3 by 18-foot (i.e. 6 SY) treated test plots of wheat in Field A to ascertain effects of LN-14 and LN-33 on established wheat. LN-14 was applied in concentrations of 5, 10, and 15 pounds per acre (i.e. 0.47, 0.94 and 1.41 grams per square yard) with four replicates. Given this information, **approximately 67.48 grams LN-14 were used for this test.**

2.3.26 Soil Application – Plant Inhibitor Comparisons, 1947 Experiment 3

Camp Detrick conducted this experiment on 1 by 9-foot (i.e. 1 SY) treated test plots of soybeans in Field C to compare the effectiveness of 19 LN agents including three 2,4,5-T: LN-951, 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid and 2,4-dichlorophenyl 2,4,5-Trichlorophenoxyacetic acid applied in concentrations of 0.5 and 2 grams per square yard) with two replicates. Given this information, **approximately 5 grams of each LN-951, 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid and 2,4-dichlorophenyl 2,4,5-Trichlorophenoxyacetic acid were used for this test (total 15 grams of 2,4,5-T agents).**

2.3.27 Soil Application – Stage of Development Study, 1947 Experiment 1

Camp Detrick conducted this experiment on 5 by 8-foot test plots of winter wheat in Field A with LN-33. No 2,4,5-T agents were used in this experiment.

2.3.28 Soil Application – Particle Size and Agent Percentage, 1947 Experiment 1

Camp Detrick conducted this experiment on 6 by 18-foot (i.e. 12 SY) test plots of soybeans in Field C to ascertain the effect of the percent of agent and particle size using LN-14 in a commercial form produced by Dow Chemical. LN-14 agent was applied in four forms of extruded materials. The test used small pellets, large pellets, impregnated sawdust and impregnated Fuller's earth (clay) in concentrations of 25%, 50%, 75%, and 97/97% with application rates of 0.5, 1.0 and 2.0 grams per square yard with four replicates with three controls. Given this information, **approximately 1416.24 grams of LN-14 were used for this test.**

2.3.29 Soil Application – Persistence in Soil, 1946 Experiment 1

Camp Detrick conducted this experiment on 10 by 10-foot (i.e. 11.1 SY) test plots of half soybeans and half oats in Field B to study persistence of various LN agents, including LN-14 in concentration of 0.5 and 2.0 grams per square yard (no replicates). Given this information, **approximately 27.78 grams of LN14-TEA were used for this test.**

2.3.30 Soil Application – Persistence in Soil, 1947 Experiment 1

Camp Detrick conducted this experiment on 5 by 9-foot (i.e. 5 SY) treated test plots of red kidney beans in Field A to compare the effectiveness of 21 LN agents including two 2,4,5-T: LN-14 and 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid applied in concentrations of 2 grams per square yard with no replicates. Given this information, **approximately 10 grams of each LN-14 and 2,4,6-trichlorophenyl 2,4,5-Trichlorophenoxyacetic acid were used for this test (total 20 grams of 2,4,5-T agents).**

2.3.31 Soil Application – Persistence in Soil, 1947 Experiment 2

Camp Detrick conducted this experiment on 5 by 9-foot test plots of oats and corn in Field C to test the persistence of LN-33. No 2,4,5-T agents were used in this experiment.

2.3.32 Soil Application – Observational Soil Application Studies, 1947 Experiment 1

Camp Detrick conducted this experiment on five plant varieties (i.e. oats, barley, millet, sorghum and corn) in Field C to observe the effectiveness of LN-33 versus LN-14 applied in extruded particles containing 50% agent at an agent rate of 10 lb. per acre and observing the effects at five different plant growth stages. The size of the plots is not stated but if one assumes an 18 SY plot, an **estimated 42.17 grams of each LN-14 was used for this test.**

2.3.33 Soil Application – Observational Soil Application Studies, 1947 Experiment 2

Camp Detrick conducted this experiment on ten plant varieties (i.e. potatoes, carrots, beans, beets, soybeans, peanuts, chard, cabbage, tomatoes, and sweet potatoes) in Field C to observe the effectiveness of LN-14 and LN-951 applied in extruded particles containing 50% agent at an agent rate of 3, 12, and 20 lb. per acre and observing the effects at different plant growth stages. The size of the plots is not stated but if one assumes as similar sized areas to the Observational Spray Experiments, 1947 Experiment 3 discussed previously, which had a similar variety of crops tests, an average 4.5 feet and given that 6 feet of 10 types of vegetables were tested this equates to a 270 SF or 36 SY per test group. No replicates plots were conducted for this test.), Given this information,

an **estimated 49.20 grams of each LN-14 and LN-951 was used for this test (total 98.40 grams of 2,4,5-T agents).**

2.3.34 Firebreak Vegetational Control Studies

Camp Detrick conducted this experiment on broadleaf and grassy weeds on 9 by 9-foot (i.e. 5 SY) plots "laid out in the area to the northwest of Field B" to observe the effectiveness of LN-8, LN-14 and LN-33 in control of vegetative firebreaks. LN-14 applied as impregnated Fuller's Earth dust at rates of 10, 20, and 50 lb. per acre containing 13.3% agent on plowed and unplowed plots at two stages of growth. Additionally, there were plots with split applications at rates of 5, 10, and 25 lb. per acre with half the plot receiving a second dose and half not receiving the second application. Plots of a 50/50 mix of LN-14:LN-33 mix at rates of 20 and 40 lb. per acre containing 13.3% agent were also used at only the second stage. No replicates plots were conducted for this test. Given this information, **approximately 45.99 grams of LN-14 were used for this test.**

2.4 Special Report No. 105, Field Plot Experiments with Plant Inhibitors 1948 Season – 16 August 1949[25]

2.4.1 Estimated Amount of 2,4,5-T Agents Used in 1948

The total amount of **2,4,5-T compounds used for the 1948 Field plots tests is approximately 1,544.72 grams.** This includes:

- 1,406.68 grams LN-14 (2,4,5-Trichlorophenoxyacetic acid (2,4,5-T))
  - ~875.30 grams in Field D
  - ~295.21 grams in Location B
  - ~236.17 grams in Location A
- 1.80 grams 43% isopropyl 2,4,5-T (isopropyl 2,4,5-Trichlorophenoxyacetate with in Field D
- 10.00 grams LN-974 (butyl 2,4,5-Trichlorophenoxyacetate) in Field D
- 116.24 grams LN-2426 (2,4,5-Trichlorophenoxyacetic anhydride) with in Field D
- ~10.00 grams LN-2777 (isopropyl 2,4,5-Trichlorophenoxyacetate) with in Field D

The following sub-paragraphs summarize the 1948 field plot tests in general and specifically those that deal with 2,4,5-T and its variants.

2.4.2 Overview of Special Report No. 105

In 1948, C Division continued conducting field plot experiments with plant inhibitors at Camp Detrick. The experiments were an extension of the previous field work published in Special Report Nos. 79 and 92 described above and conducted in 1944 through 1947. The primary objectives were:

"a) ascertain the most effective agent for causing yield reductions for various crops
b) to ascertain the best methods of application
c) to determine the effect of stages of development on plant response"

The test locations are identified as Fields C, D, and E with two additional locations of unplowed grasses also used (A& B, 115 feet north and 570 feet east of Field C respectively). Though the specific field locations are not specified, Field D is about 4 acres in size and west of Field C. Field E is about 6 acres in size and approximately 1,400 feet northwest of the Commanding Officer's Quarters.

The described field trials were not large scale tests, such as spraying by aircraft. The equipment used to apply the agent was handheld sprayers, specifically the DeVilbiss types MBC spray gun to the tops of the plants. In the vegetation control experiments and for application to the soil surface, a CWS 3 gallon sprayer (M1) originally designed for decontaminating was used. As before, to prevent drift of spray or dust, a movable, 5-foot high, light metal framed chamber or shelter with wind resistant cloth was used.

2.4.3 Volume-Concentration Spray Studies, Experiment 1

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 81 SF or 9 SY) test plots of soybeans in Field D to test volume of spray on growth inhibiting qualities of LN-14 in a 1%Tween 20 (a commercial polysorbate surfactant) aqueous solution. LN-14 in a concentration of 0.0025 and 0.0075 grams per square yard and at three different spray volumes were compared, with four replicates of these tests. Given this information, **approximately 1.08 grams of LN-14 were used for this test.**

2.4.4 Volume-Concentration Spray Studies, Experiment 2,

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of soybeans in Field D to test volume of spray on growth inhibiting qualities of LN-14 in a 1%Tween 20 (a commercial polysorbate surfactant) aqueous solution. The tests used LN-14 in a concentration of 0.0025 and0.005 grams per square yard and at three different spray volumes, with four replicates of these tests. Given this information, **approximately 0.81 grams of LN-14 were used for this test**.

2.4.5 Volume-Concentration Spray Studies, Experiment 3

Camp Detrick conducted this experiment on 3 1/3 by 18-foot (i.e. 6.67 SY) test plots of wheat in Field E and used LN-33 (isopropyl phenyl carbamate). No 2,4,5-T agents were used in this experiment.

2.4.6 Stage of Development Spray Studies, Experiment 1

Camp Detrick conducted this experiment on 3 1/3 by 18-foot (i.e. 6.67 SY) test plots of wheat in Field C and used LN-33 (isopropyl phenyl carbamate). No 2,4,5-T agents were used in this experiment.

2.4.7 Stage of Development Spray Studies, Experiment 2

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of soybeans in Field D to compare LN-14 and LN-2426 (2,4,5-Trichlorophenoxyacetic anhydride) at three different concentrations (0.0025. 0075 and 0.025 grams per square yard) and at three different stages of development of the plant, with four replicates of these tests. Given this information, **approximately 3.78 grams each of LN-14 and LN-2426 were used for this test**.

2.4.8 Carrier Spray Experiment

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of soybeans in Field D to compare the effectiveness of seven carriers (e.g. oils, water with detergents, water) of LN-8 at two different concentrations (0.015 and 0.030 grams per square yard) against two controls (16 test groups total). No 2,4,5-T agents were used in this experiment.

2.4.9 Coagent Spray Experiment

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of oats in Field E to compare the effectiveness of mixing certain coagents with LN-8 (and LN-33) (8 test groups total). No 2,4,5-T agents were used in this experiment.

2.4.10 Agent Comparison Spray Experiments, Experiment 1

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of soybeans in Field D to compare the effectiveness of LN-14 versus LN-8, LN-143 (butyl 2,4-Dichlorophenoxyacetate, normal butyl ester of LN-8), LN-719 (triethanolamine 2-bromo- 3,5-Dichlorobenzoate), and two commercial formulations in both water and diesel oil carriers: Esteron 44 (isopropyl 2,4-Dichlorophenoxyacetate) and 43% isopropyl 2,4,5-T (isopropyl 2,4,5-Trichlorophenoxyacetate) in concentrations of 0.005 and 0.020 grams per square yard, with four replicates of these tests. Given this information, **approximately 0.90 grams of LN-14 were used for this test and twice**

that amount of 43% isopropyl 2,4,5-T (isopropyl 2,4,5-Trichlorophenoxyacetate), or 1.80 grams of 2,4,5-T agents were used.

2.4.11 Agent Comparison Spray Experiments, Experiment 2

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of sugar beets in Field D to compare the effectiveness of LN-14 versus LN-8 in three different aqueous and non-aqueous carriers in concentrations of 0.010 and 0.025 grams per square yard, with four replicates of these tests. Given this information, **approximately 3.78 grams of LN-14 were used for this test**.

2.4.12 Agent Comparison Spray Experiments, Experiment 3

Camp Detrick conducted this experiment on 7.5 by 20-foot (i.e. 150 SF or 16.67 SY) test plots of Irish potatoes in Field D. LN-14 in a concentration of 0.015 grams per square yard was compared with two versions each of LN-974 (butyl 2,4,5-Trichlorophenoxyacetate) and LN-2777 (isopropyl 2,4,5-Trichlorophenoxyacetate) in a concentration of 0.015 or 0.060 grams per square yard, with four replicates of these tests. Given this information, **approximately 1.00 grams of LN-14, approximately 10.00 grams each of LN-974 and LN-2777 were used for this test**.

2.4.13 Field Plot Technique-Sampling of Treated Plots

Camp Detrick conducted this experiment with the materials and methods "precisely the same as " Volume-Concentration Spray Studies, Experiment 2 noted above. Given this information, **approximately 0.8100 grams of LN-14 were used for this test** in Field D.

2.4.14 Soil Application - Agent Comparison-Stage of Development on soybeans

Camp Detrick conducted this experiment on 4.5 by 9-foot (i.e. 4.5 SY) test plots of soybeans in Field D to compare the effectiveness of LN-14, LN-719 (triethanolamine 2-bromo- 3,5-Dichlorobenzoate) and LN-2426 (2,4,5-Trichlorophenoxyacetic anhydride) at two different concentrations of 5 and 15 lbs. per acre (or 0.4686 and 1.4058 grams per square yard) at three different stages of plant growth, versus a control group of , with four replicates of these tests. Given this information, **approximately 101.21 grams each of LN-14 and LN-2426 were used for this test**.

2.4.15 Soil Application – Comparison of LN-14 on soybeans, Experiment 1

Camp Detrick conducted this experiment on a 6 by 18-foot test plots, with only the middle 4.5 feet treated (i.e. 9 SY) test plots of soybeans in Field D to compare the effectiveness of LN-14 at three different concentrations of 5, 10, and 20 lbs. per acre (or 0.4686, 0.9372 and 1.8743 grams per square yard) at three different stages of plant

growth, with four replicates of these tests. Given this information, **approximately 354.25 grams of LN-14 were used for this test.**

2.4.16 Soil Application – Comparison of LN-14 on soybeans, Experiment 2

Camp Detrick conducted this experiment on 6 by 18-foot test plots, with only middle 4.5 feet treated (i.e. 9 SY) test plots of soybeans in Field D to compare differing solubilities of LN-14 in three different forms (acid, Na salt and triethanolamine [TEA] salt) at three different concentrations of 5, 10 and 20 lbs. per acre (or 0.4686, 0.9372 and 1.8743 grams per square yard) at two different stages of plant growth versus three controls, with four replicates of these tests. Given this information, **approximately 354.25 grams of LN-14 were used for this test.**

2.4.17 Soil Application – Agent Comparison on Soybeans

Camp Detrick conducted this experiment on 4.5 by 9-foot (i.e. 4.5 SY) test plots of soybeans in Field D to compare effectiveness of LN-14 with 8 benzoic acids at two different concentrations of 5 and 20 lbs. per acre (or 0.4686 and 1.8743 grams per square yard) versus one control, with four replicates of these tests. Given this information, **approximately 42.17 grams of LN-14 were used for this test.**

2.4.18 Soil Application – Agent Comparison on Cereals

Camp Detrick conducted four experiment series using carbamates and benzoic acids on oats and winter wheat in Field E but did not include any testing of LN-14; no 2,4,5-T used.

2.4.19 Soil Application – Comparison of Isopropyl N-phenyl Carbamates on Cereals

Camp Detrick conducted two experiment series on winter wheat in Field C and spring oats in Field E but did not include any testing of LN-14; no 2,4,5-T used.

2.4.20 Soil Application – Persistence Study

Camp Detrick conducted this experiment on a series of 4.5 by 6-foot test plots (i.e. 3 SY) test plots of kidney beans in Field D to compare the persistence of LN-14 and a variety of other LN agents including LN-2426, at a concentration of 20 lbs. per acre (or 1.8743 grams per square yard), with only two replicates of these tests. Given this information, **approximately 11.25 grams of LN-14 and LN-2426 were used for this test for the two test plots; however the report states 6 grams were applied per plot.**

2.4.21 Vegetation Control of Unplowed Areas

Camp Detrick conducted this experiment at Locations A & B 115 feet north and 570 feet east of Field C. Location A & B contained broadleaf and annual grasses and Kentucky bluegrass, respectively. Tests were conducted, 9 by 9-foot test plots (i.e. 9 SY) with LN-14 at concentration of 20 and 50 lbs. per acre (or 1.8743 and 4.6859 grams per square yard). It appears that two plots in Location B received a single application (one at 20 and one at 50) and the two plots in both Locations A & B received four applications of this concentration. Given this information, **approximately 295.21 grams of LN-14 in Location B and 236.17 grams in Location A were used for this test.**

2.5 Special Report No. 130, Field Plot Experiments with Plant Inhibitors 1949 Season – 14 April 1950[26]

2.5.1 Estimated Amount of 2,4,5-T Agents Used in 1949

The total amount of **2,4,5-T compounds used for the 1949 Field plots tests is approximately 76.18 grams**. This includes:

- 0.90 grams LN-14 ((NH_4) 2, 4, 5-trichlorophonoxyacetic acid) in Field C
- 6.16 grams LN-14 (TEA) (Triethanolamine 2,4,5-Trichlorophenoxyacetate) in Field C
- 69.13 grams LN-974 (Butyl 2,4,5-trichlorophenoxyacetate) in Field C

The following sub-paragraphs summarize the 1949 field plot tests in general and specifically those that deal with 2,4,5-T and its variants.

2.5.2 Overview of Special Report No. 130

C Division continued conducting field plot experiments with plant inhibitors in 1949 at Camp Detrick. The experiments were an extension of the previous field work published in Special Report Nos. 79, 92, and 105 described above and conducted in 1944 through 1948, with the primary objectives remaining the same. The test locations are identified as Fields C, D, and E. As before, the described field trials were small scale tests using hand held sprayers (i.e. DeVilbiss types MBC spray gun) or a glass droplet-sizer with a movable light metal framed chamber to prevent drift of spray or dust.

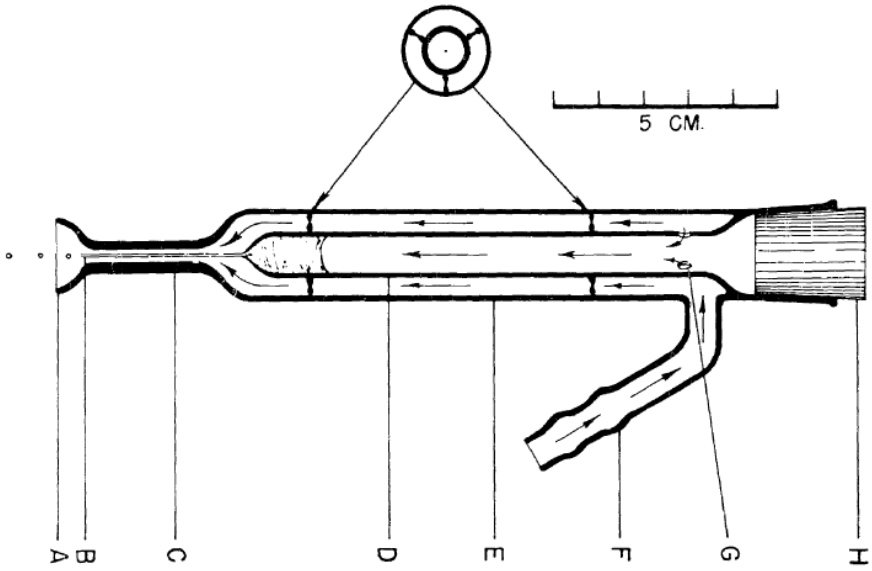

Figure 6 – *Drawing of glass droplet-sizer used in applying extremely low-volume top treatments and in making droplet-size applications*[27]

2.5.3 Volume-Concentration Spray Studies, Experiment 1

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 81 SF or 9 SY) test plots of soybeans in Field C to test volume of spray on growth inhibiting qualities of LN-14 (TEA) in three different carriers: water, 1% Tween 20 and 5% oil emulsion at two different concentration of 0.004 and 0.008 grams per square yard, against two controls, with four replicates for each test plot. Given this information, **approximately 3.89 grams of LN-14 TEA were used for this test.**

2.5.4 Volume-Concentration Spray Studies, Experiment 2

Camp Detrick conducted this experiment on one row (presumably 18-inches wide) by 18-foot (i.e. 3 SY) test plots of soybeans in Field C to test three rates of volume of spray on growth inhibiting qualities of LN-14 (TEA) and LN-974 (butyl 2,4,5-Trichlorophenoxyacetate) at a concentration of 0.008 grams per square yard, against a control, with four replicates for each test plot. Given this information, **approximately 0.29 grams of LN-14 TEA and 0.29 grams of LN-974 were used for this test.**

2.5.5 Volume-Concentration Spray Studies, Experiment 3

Camp Detrick conducted this experiment on 1.5 by 18-foot (i.e. 3 SY) treated test plots of wheat in Field D and used LN-2464 (isopropyl N-(3-chlorophenyl) carbamate). No 2,4,5-T agents were used in this experiment.

2.5.6 Stage of Development Spray Studies, Experiment 1

Camp Detrick conducted this experiment on 4.7 by 18-foot (i.e. 9.4 SY) test plots of Rye in Field D and used LN-33 (isopropyl phenyl carbamate). No 2,4,5-T agents were used in this experiment.

2.5.7 Stage of Development Spray Studies, Experiment 2

Camp Detrick conducted this experiment on 4.7 by 18-foot (i.e. 9.4SY) test plots of wheat in Field D and used LN-33 (isopropyl phenyl carbamate). No 2,4,5-T agents were used in this experiment.

2.5.8 Carrier Spray Experiment, Experiment 1

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of soybeans in Field C to compare the effectiveness of LN-14 in two different carriers and LN-14 (TEA) in three carriers at concentration of 0.0045 and 0.0090 grams per square yard, with four replicates of these tests. Given this information, **approximately 0.90 grams of LN-14 and approximately 1.46 grams of LN-14 TEA were used for this test**.

2.5.9 Carrier Spray Experiment, Experiment 2

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of soybeans in Field C to compare the effectiveness of LN-8 and LN-8 (TEA) in different carriers and concentration, with four replicates of these tests. No 2,4,5-T agents were used in this experiment.

2.5.10 Carrier Spray Experiment, Experiment 3

Camp Detrick conducted this experiment offsite at the Rhode Island Agricultural Experiment Station in Kingston, RI. This testing is included in the Department of Veterans Affairs web site "Agent Orange: Herbicide Tests and Storage in the U.S.".

2.5.11 Agent Comparison Spray Experiments, Experiment 1

Camp Detrick conducted this experiment on 4.7 by 18-foot (i.e. 9.4 SY) treated test plots of wheat in Field D and used LN-33 and LN-2464 (isopropyl N-(3-chlorophenyl) carbamate). No 2,4,5-T agents were used in this experiment.

2.5.12 Agent Comparison Spray Experiments, Experiment 2

Camp Detrick conducted this experiment on 4.7 by 18-foot (i.e. 9.4 SY) treated test plots of white onions in Field C to compare the effectiveness of LN-974 (butyl 2,4,5-Trichlorophenoxyacetate), LN-143 (butyl 2,4-Dichlorophenoxyacetate, normal butyl ester of LN-8) and a 1:1 combination of the two in concentrations of 0.025, 0.1, and 0.20 grams per square yard at two plant growth stages, with three replicates of these tests. Given this information, **approximately 5.85 grams of LN-974 were used for this test**.

2.5.13 Agent Comparison Spray Experiments, Experiments 3-14

Camp Detrick conducted a series of experiments following the same methods and materials as in Experiment 2 above except the test plots were of different crops as noted below.

Experiment No.	Crop	Approx. of LN-974	Comments
3	Flax	**5.85**	
4	Peanuts	**2.93**	only one plant growth stage was tested
5	Kale	**5.85**	
6	Rutabaga	**5.85**	
7	Rutabaga	**5.85**	
8	Mangel	**5.85**	
9	Sugar Beet	**5.85**	
10	Garden Beet	**5.85**	
11	Cabbage	**5.85**	
12	Eggplant	**5.85**	
13	Rape	**2.93**	only one plant growth stage was tested
14	Tobacco	**2.93**	only one plant growth stage was tested

2.5.14 Droplet Spray Studies, Experiments 1 (Droplet Size)

Camp Detrick conducted this experiment on 18 inch by 18-foot (i.e. 3 SY) test plots of soybeans in Field C to compare the effectiveness of LN-974 (butyl 2,4,5-Trichlorophenoxyacetate) and LN-14 (TEA) (Triethanolamine-2,4,5-Trichlorophenoxyacetate) in concentrations of 0.005 and 0.0167 grams per square yards, each test conducted with a spray set for large droplets and for small droplets, with four replicates of each tests. Given this information, **approximately 0.52 grams of LN-974 and LN-14 (TEA) were used for these tests**.

2.5.15 Droplet Spray Studies, Experiments 2 (Minimum Number of Droplets per Unit Area

Camp Detrick conducted this experiment on 18 inch by 18-foot (i.e. 3 SY) test plots of soybeans in Field C to compare various concentrations of LN-974 (butyl 2,4,5-Trichlorophenoxyacetate) in #2 diesel oil Concentrations of 0.005 and 0.0167 grams per square yards were sprayed using agent/diesel mixtures of 1.5, 3, 7.5, and 15%, with four replicates of each tests. Given this information, **approximately 1.04 grams of LN-974 was used for these tests**.

2.6 Special Report No. 153, Field Plot Experiments with Plant Inhibitors, 1950 Season[28]

2.6.1 Estimated Amount of 2,4,5-T Agents Used in 1950

The total amount of **2,4,5-T compounds used for the 1950 Field plots tests is approximately 399.81 grams.** This includes:

- 2134.35 grams LN-14 (2,4,5-Trichlorophenoxyacetic acid (2,4,5-T))
  - ~21.60 grams in Field A
  - ~90.58 grams in Field D
  - ~84.0 grams in Field E
- 203.64 grams LN-974 (butyl 2,4,5-Trichlorophenoxyacetate)
  - ~203.58 grams in Field D
  - ~0.06 grams in Field F

Alternately this breaks out as approximately the following amounts in the following areas:

- ~21.60 grams in Field A
- ~294.16 grams in Field D
- ~84.0 grams in Field E
- ~0.06 grams in Field F

The following sub-paragraphs summarize the 1950 field plot tests in general and specifically those that deal with 2,4,5-T and its variants.

2.6.2 Overview of Special Report No. 153

The Crops Division of the Chemical Corps Biological Laboratories at Camp Detrick continued conducting field plot experiments with plant inhibitors in 1950 through 1951 as an extension of the previous field work published in Special Report Nos. 79, 92, 105, and 130 described above and conducted in 1944 through 1949, with the primary objectives

remaining the same. The test locations for the small plot experiments in this period were conducted Fields A, D and E, described in the previous reports and a single test in Field F, not described in Special Report No. 153 (however, it is in No. 156). As in previous years, to prevent drift of spray or dust during the applications of herbicidal materials, a movable chamber having a light metal frame and covered with a wind resistant cloth, was placed around the plots. The chamber was 5 ft tall and could be adjusted to fit the various size plots used in the experiments.

2.6.3 Stage of Development Spray Studies, Experiment 3[iv]

Camp Detrick conducted this experiment on 9 by 18-foot (i.e. 18 SY) test plots of wheat in Field A to compare the effectiveness of LN-974 against butyl ester of 2,4-D at two plant in concentration of 0.1 and 0.2 grams per square yard, with two replicates of these tests. Given this information, **approximately 21.60 grams of LN-974 was used for this test**.

2.6.4 Minimum Volume Spray Studies, Experiment 1

Camp Detrick conducted this experiment on 6 by 18-foot (i.e. 12 SY) test plots of flax in Field D to determine the minimum volume of highly concentrated formulations of agent on growth inhibiting qualities of LN-974 in a concentrations of 0.0096, 0.024, 0.048 and 0.096 grams per square yard, with three replicates of these tests. Given this information, **approximately 6.39 grams of LN-974 were used for this test.**

2.6.5 Minimum Volume Spray Studies, Experiment 2

Camp Detrick conducted this experiment on 7.5 by 18-foot (i.e. 15 SY) test plots of Irish potatoes in Field D to determine the minimum volume of highly concentrated formulations of agent on growth inhibiting qualities of LN-974 in a 96% volume concentrations of agent applied at 0.025, 0.050, 0.075, and 0.1 ml per SY, with two replicates of these tests. Given that 2,4,5-T has a density of 1.8[29], this equates to 0.0432, 0.0865, 0.1298, and 0.1731 grams per square yard. Given this information, **approximately 12.98 grams of LN-974 were used for this test.**

2.6.6 Minimum Volume Spray Studies, Experiment 5

Camp Detrick conducted this experiment on test plots of soybeans in Field D to determine the minimum volume of highly concentrated formulations of agent on growth inhibiting qualities of LN-974 in a 90% volume concentrations of agent applied at 0.0045, 0.009, 0.018, 0.027, and 0.045 ml per SY, with three replicates of these tests. Given that 2,4,5-T has a density of 1.8, this equates to 0.0073, 0.0146, 0.0292, 0.0438,

[iv] For Special Reports No.150 and No. 156, only the test where a 2,4,5-T compound are being used are discussed, hence the starting on Experiment 3.

and 0.0730 grams per square yard. The test plot size was not specified but the area harvested is noted as 3 rows 16.5 feet long with an 18 inch row spacing, which should equate to 7.5 by 18-foot (i.e. 15 SY). Given this information, **approximately 7.56 grams of LN-974 were used for this test.**

2.6.7 Droplet-Size Spray Studies, Experiments 2

Camp Detrick conducted this experiment on 7.5 by 18-foot (i.e. 15 SY) test plots of Irish potatoes in Field D to determine effect of large and small droplets on low volume of applications of a 96% volume concentrations of LN-974 at application rates of 0.1 and 0.2 ml per square yard, with three replicates of these tests. Given that 2,4,5-T has a density of 1.8, this equates to 0.1730 and 0.3461 grams per square yard. Given this information, **approximately 46.73 grams of LN-974 were used for this test.**

2.6.8 Droplet-Size Spray Studies, Experiments 3

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 9 SY) test plots of flax in Field D to determine effect of three droplet sizes on low volume of applications of a 96% volume concentrations of LN-974 at application rates of 0.025 and 0.050 ml per square yard, with four replicates of these tests. Given that 2,4,5-T has a density of 1.8, this equates to 0.0433 and 0.0865 grams per square yard. Given this information, **approximately 46.73 grams of LN-974 were used for this test.**

2.6.9 Droplet-Size Spray Studies, Experiments 5

Camp Detrick conducted this experiment on 6 by 18-foot (i.e. 12 SY) test plots of soybeans in Field D to determine effect of four droplet sizes on low volume of applications of a 90% volume concentrations of LN-974 at application rates of 0.02 and 0.040 ml per square yard, with four replicates of these tests. Given that 2,4,5-T has a density of 1.8, this equates to 0.0324 and 0.0865 grams per square yard. Given this information, **approximately 18.69 grams of LN-974 were used for this test.**

2.6.10 Agent Comparison Spray Study, Experiments 1-7

Camp Detrick conducted these experiments on test plots of seven various crops in Field D to compare the effectiveness of LN-974 versus LN-143 and a 1:1 combination of the two in concentrations of 0.010, 0.025 and 0.50 grams per square yard at two plant growth stages, with three to four replicates of these tests at the noted test plot size. Given this information, the following table provides the approximate amounts of LN-974 used for each of these tests.

Experiment No.	Crop	Test Plot Size (additional comments)	Replicates	Approx. of LN-974 (grams)
1	Fiber Flax	3 by 18-foot (i.e. 6 SY)	3	**4.59**

Experiment No.	Crop	Test Plot Size (additional comments)	Replicates	Approx. of LN-974 (grams)
2	Oil Flax	3 by 18-foot (i.e. 6 SY)	3	**4.59**
3	Sunflowers	3 SY	3	**2.30**
4	Sweet Corn	7.5 by 18-foot (i.e. 15 SY)	3	**11.48**
	Sweet Corn	7.5 by 18-foot (i.e. 15 SY) 2nd LN-974 test group at 0.1 and 0.25 grams/SY (no LN-974 mix tested)	4	**42.00**
5	Sorghum	7.5 by 18-foot (i.e. 15 SY) 3 plant stages at 0.1 grams/SY and 1 at 0.25 (no LN-974 mix tested)	3	**24.75**
6	Irish Potatoes	7.5 by 18-foot (i.e. 15 SY) 1 plant stages at 0.025 and 0.1 grams/SY(no LN-974 mix tested)	4	**7.50**
7	Soybeans	1.5 by 18-foot (i.e. 3 SY) 1 plant stages at 0.05 lbs/acre (0.0047 grams/SY) (no LN-974 mix tested) Field F	4	**0.06**

This equates to **approximately 97.20 grams of LN-974 used for this test in Field D and 0.06 grams in Field F.**

2.6.11 Persistence of Plant Inhibitors in Progeny of Treated Plants, Experiment 1

Camp Detrick conducted this experiment on 1.5 by 18-foot (i.e. 3 SY) test plots of red kidney beans in Field D to compare the effectiveness of LN14 versus LN-8 and LN-719 (triethanolamine 2-bromo- 3,5-Dichlorobenzoate) at five different plant growth stages applied in concentrations of 0.001, 0.005, and 0.015 grams per square yard with four replicates. Given this information, **approximately 1.25 grams of each LN-14 were used for this test.**

2.6.12 Persistence of Plant Inhibitors in Progeny of Treated Plants, Experiment 2

Camp Detrick conducted this experiment on 2 by 10-foot (i.e. 2.2 SY) test plots of red kidney beans in Field D to compare the effectiveness of LN14 versus LN-8 and LN-719 at five different plant growth stages in concentrations of 1, 5, and 9 lbs/acre (equivalent to 0.0937, 0.4686, and 0.8435 grams per square yard) with four replicates. Given this information, **approximately 62.48 grams of each LN-14 were used for this test.**

2.6.13 Top Application Dust Study, Agent Rate Comparison

Camp Detrick conducted this experiment on test plots of soybeans in Field D to ascertain effects of various rates of LN-14 upon yield of soybeans applied at 0.01, 0.025, 0.050 and 0.1 grams per square yard with four replicates. The test plot size was not specified but the area harvested is noted as 3 rows 16.5 feet long with an 18 inch row spacing, which should equate to 7.5 by 18-foot (i.e. 15 SY). Given this information, **approximately 11.10 grams of LN-974 were used for this test.**

2.6.14 Top Application Dust Study, Minimum Amount of Dust Study

Camp Detrick conducted this experiment on test plots of soybeans in Field D to ascertain effects of various rates of LN-14 upon yield of soybeans applied at 0.05, 0.1 and 0.2 grams per square yard with three replicates. The test plot size was not specified but the area harvested is noted as 3 rows 16.5 feet long with an 18 inch row spacing, which should equate to 7.5 by 18-foot (i.e. 15 SY). Given this information, **approximately 15.75 grams of LN-974 were used for this test.**

2.6.15 Vegetation Control Studies

Camp Detrick conducted this experiment on 22 inches by 10-foot (i.e. 2 SY) test plots of plowed bare earth and mowed annual grasses in Field E to compare the effectiveness LN-14, three 1:1 mixes of LN-14 and other growth inhibitors at concentration of 0.3, 0.6 and 1.2 grams per square yard on plowed and unplowed plots with four replicates. Given this information, **approximately 84.0 grams of LN-14 were used for this test**.

2.7 Special Report No. 156, Field Plot Experiments with Plant Inhibitors, 1950-51 Season – 25 August 1952[30]

2.7.1 Estimated Amount of 2,4,5-T Agents Used in 1950-51

The total amount of **2,4,5-T compounds used for the 1950-51 Field plots tests is approximately 460.87 grams.** This includes:

- 29.294 grams LN-14 (2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)) in Field F
- 0.2109 grams LN-14 (TEA) (Triethanolamine 2,4,5-Trichlorophenoxyacetate) in Field F
- 419.9857 grams LN-974 (butyl 2,4,5-Trichlorophenoxyacetate) in Field F
- 5.6230 grams LN-1856 (alpha-(2,4,5-Trichlorophenoxy)-propionic acid) in Field F
- 5.6230 grams LN-2426 (2,4,5-Trichlorophenoxyacetic anhydride) in Field F

The following sub-paragraphs summarize the 1950 through 1951 field plot tests in general and specifically those that deal with 2,4,5-T and its variants.

2.7.2 Overview of Special Report No. 156

The Crops Division of the Chemical Corps Biological Laboratories at Camp Detrick continued conducting field plot experiments with plant inhibitors in 1950 though 1951 as an extension of the previous field work published in Special Report Nos. 79, 92, 105, 130, and 153 described above and conducted in 1944 through 1950, with the primary objectives remaining the same. The test locations for the small plot experiments in this period were conducted in the 16 acres Field F, which is reported as at the northern most area of Camp Detrick. As in previous years, to prevent drift of spray or dust during the applications of herbicidal materials, a movable chamber, having a light metal frame and covered with a wind resistant cloth, was placed around the plots.

2.7.3 Application of 4 Different Droplet Sizes of 974 to soybeans

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 81 SF or 9 SY) test plots of soybeans in Field F to test effect of droplet size on growth inhibiting qualities of LN-974 in a 90% solution of Velsicol AR-55 saturated with Du Pont oil red dye. LN-974 was used in a concentration of 0.01675 grams per square yard with four different droplet sizes, with four replicates of these tests. Given this information, **approximately 2.41 grams of LN-974 were used for this test.**

2.7.4 Application of 100% LN-143 and 96% LN-974 to Various Agricultural Crops

Camp Detrick conducted the following series of experiments on test plots of types of agricultural plants to determine the effectiveness of LN-143 (100% solution) and LN-974 (96% solution). These tests involved spraying LN-974 in three different concentrations: 0.00937, 0.023429, and 0.046859 grams per square yard with four replicates for each test. The plot size represents one 18-foot long row of each plant type. The following table summarizes this series of tests.

Crop	Plot Size	Approximate Amount of LN-974 Used
Lima Beans	2.5 by 18 feet	**1.59 grams**
String Beans	2.5 by 18 feet	**1.59 grams**
Kale	2 by 18 feet	**1.27 grams**
Sunflower	2.5 by 18 feet	**1.59 grams**
Sweet Peppers	2.5 by 18 feet	**1.59 grams**
Tomatoes	3 by 18 feet	**1.91 grams**

Crop	Plot Size	Approximate Amount of LN-974 Used
Eggplant	2.5 by 18 feet	**1.59 grams**
Hemp	2 by 18 feet	**1.27 grams**
Peanuts	3 by 18 feet	**1.91 grams**
Rutabaga (Swede)	2 by 18 feet	**1.27 grams**
Mangels	2 by 18 feet	**1.27 grams**
Sugar Beets	2 by 18 feet	**1.27 grams**
Sweet Potatoes	3 by 18 feet	**1.91 grams**
Tobacco	3 by 18 feet	**1.91 grams**

This equates to **approximately 21.99 grams of LN-974 used for this test.**

2.7.5 Application of 96% LN-974 to Oil Flax

Camp Detrick conducted this experiment on 2 by 18-foot (i.e. 36 SF or 4 SY) test plots of oil flax in Field F to test effectiveness on growth inhibiting qualities of LN-974 in a 96% solution of Tributylphosphate, with four replicates of these tests. Given this information, **approximately 1.27 grams of LN-974 were used for this test.**

2.7.6 Application of 96% LN-974 to Irish Potatoes at Three Stages of Development

Camp Detrick conducted this experiment on 2.5 by 18-foot (i.e. 45 SF or 5 SY) test plots of Irish potatoes in Field F to test effectiveness on growth inhibiting qualities of LN-974 in a 96% solution of Tributylphosphate. LN-974 at three different times in four concentrations of 0.23429, 0.468587, 937174, and 1.874349 grams per square yard, with 6 replicates of these tests. Given this information, **approximately 316.30 grams of LN-974 were used for this test.**

2.7.7 Application of 3 Rates of LN-143, LN-974, LN-1700, and LN-2464 to Winter Wheat at Three Stages of Plant Development

Camp Detrick conducted this experiment on 3.5 by 18-foot (i.e. 63 SF or 7 SY) test plots of winter wheat in Field F to test effectiveness on growth inhibiting qualities of LN-974 verses LN agents 143,1700, and 2464. LN-974 was applied at three different times in three concentrations of 0.05, 0.1, and 0.3 grams per square yard, with four replicates of these tests. Given this information, **approximately 37.8 grams of LN-974 were used for this test.**

2.7.8 Application of LN-620, LN-658, LN-761, and LN-14 to Soybeans at Two Stages

Camp Detrick conducted this experiment on 2 by 18-foot (i.e. 36 SF or 4 SY) test plots of soybeans in Field F to test effectiveness on growth inhibiting qualities of LN-14 verses LN agents 620, 658, and 761. LN-14 was applied at two different times in two concentrations of 0.014 and 0.0047 grams per square yard, with four replicates of these tests. Given this information, **approximately 0.60 grams of LN-974 were used for this test.**

2.7.9 Application of LN-14, LN-1856, and LN-2426 on Irish potatoes at Two Stages

Camp Detrick conducted this experiment on 2 by 18-foot (i.e. 36 SF or 4 SY) test plots of soybeans in Field F to test effectiveness on growth inhibiting qualities of LN-14 verses LN agents 1856, and 2426. LN-14, 1856, and 2426 were applied at two different times in two concentrations of 0.014 and 0.0047 grams per square yard, with four replicates of these tests. Given this information, **approximately 5.62 grams each of LN-14, LN-1856, and LN-2426 were used for this test.**

2.7.10 Application to Potatoes of Various Organic and Inorganic Compounds Alone and in Combination with LN-974

Camp Detrick conducted this experiment on 2.5 by 18-foot (i.e. 45 SF or 5 SY) test plots of Irish potatoes in Field F to test effectiveness on growth inhibiting qualities of LN-974 and LN-974 mixed with inorganic compounds. LN-974 was applied in concentrations of 0.05, 0.075, and 0.125 grams per square yard, unmixed and mixed with each of five different inorganic compounds, with four replicates of these tests. Given this information, **approximately 17.5 grams of LN-14 were used for this test.**

2.7.11 Application of 0.5 and 1.5 pounds per acre of LN-1856, LN-1999, and LN-14 to Soybeans

Camp Detrick conducted this experiment on 4.5 by 18-foot (i.e. 81 SF or 9 SY) test plots of soybeans in Field F to test effectiveness on growth inhibiting qualities of LN-14 verses LN agents 1856, and 1999. LN-14 was applied in two concentrations of 0.005 and 0.015 grams per square yard, with four replicates of these tests. Given this information, **approximately 0.72 grams of LN-14 were used for this test.**

2.7.12 LN-14 (TEA) with Additives on Black Valentine Beans

Camp Detrick conducted this experiment on two SY test plots of Black Valentine Beans in Field F to test effectiveness on growth inhibiting qualities of LN-14 and LN-14 (TEA) mixed with H3PO4, LN 539, and LN 1999. LN-14 (TEA) for all applications was in a concentration of 0.0625grams per square yard (mixtures used different application rates to equate to the LN-14 dose rate of 0.0625 grams/SY), with three replicates of these tests. Given this information, **approximately 0.2109 grams of LN-14 (TEA) were used for this test.**

2.7.13 LN-8 and LN-14 with Additives on Sweet Potatoes

Camp Detrick conducted this experiment on 2.5 by 18-foot (i.e. 45 SF or 5 SY) of sweet potatoes in Field F to test effectiveness on growth inhibiting qualities of LN-14 and LN-14 mixed with KSCN and LN 539. LN-14 for all applications was in two concentration of 0.00469 and 0.009372grams per square yard (mixtures used different application rates to equate to the LN-14 dose rates), with two replicates of these tests. Given this information, **approximately 0.4218 grams of LN-14 were used for this test.**

2.7.14 Effect of LN-143 and LN-974 Applications on the Progeny of Wheat

Camp Detrick conducted this experiment on 1 by 18-foot (i.e. 18 SF or 2 SY) of wheat in Field F to test effectiveness on growth inhibiting qualities of LN-974 on early growth stages (Boot and Milk). LN-974 for all applications was in two concentrations of 0.09372 and 0.187436grams per square yard, with 1 replicates of these tests. Given this information, **approximately 1.1246 grams of LN-974 were used for this test.**

2.7.15 Effect of LN-8, LN-14, and LN-719 on the Emergence and Yield of Progeny of Kidney Beans

Camp Detrick conducted this experiment on 6 by 18-foot (i.e. 9 SF or 1 SY) of kidney beans in Field F to test effectiveness on growth inhibiting qualities of LN-14 on four different growth stages. LN-14 was applied in three dosages (0.00094, 0.004686, and 0.01406 grams per square yard). It was applied by spray and by dust (same dosage for both), with three replicates of these tests. Given this information, **approximately 0.4723 grams of LN-14 were used for this test.**

2.7.16 Top Application Dust Studies with 2, 14, and 974 on Soybeans

The last test reported in Special Report No. 156 had Camp Detrick conducting an experiment on the application of spray suspensions of agents LN-2, 14, and 974 on two different stages of growth of soybeans. The experiment was conducted on 6 x 18-foot test plots with agents dispersed with a dosage of either 0.00937 or 0.046859 grams per

square yard with four replicates of the tests. Given this information, **approximately 21.59 grams of LN-14 and 21.59 grams of LN-974 were used.**

2.8 Special Report No. :201, Field Development of Chemical Anticrop Agents, Response of Field Grown Crops to Chemical Anticrop Agents Released from Experimental Spray Tower – 15 January 1954

On 28 July 1953, Camp Detrick conducted a series of anti-crop field tests using a truck-mounted experimental spray tower (see Figure 7 below) on broad-leaf (i.e. soybean and sweet potatoes) test plots in Area B (specific location not stated). The agent tested was a "three to one mixture of butyl 2,4-Dichlorophenoxyacetate (agent 143) and butyl 2,4,5-Trichlorophenoxyacetate (agent 974)", which was the same mixture as the Air Force is using in the "MCI spray systems" tests. The sweet potatoes were planted on 30 May 1953 and the soybeans on 30 March and 15 June, with the spraying being conducted on 28 July. The spray tower applied the anti-crops agents mixture at a rate of 0.062 gallons/minute as the tower moved four miles/hour (or 352 feet/minute) across an approximate 240+ foot distance as seen on the general depiction for the test area (see Figure 8 next page). To cover the 240 feet, the spraying tower would need to be on 41 seconds but it appears likely that sprayer worked for longer, presumably a minute. In that time, 0.062 gallons would be dispersed, a quarter of which was LN-974 resulting in about 0.0156 gallons used or 59 ml (3.785.41178ml to a gallon), which at a density of 1.8 roughly this equates to **approximately 106.29 grams of LN-974 were used for this test**.[31]

Figure 7 – *Spray Tower mounted to ½ ton pick-up truck in Special Report No. 201*[32]

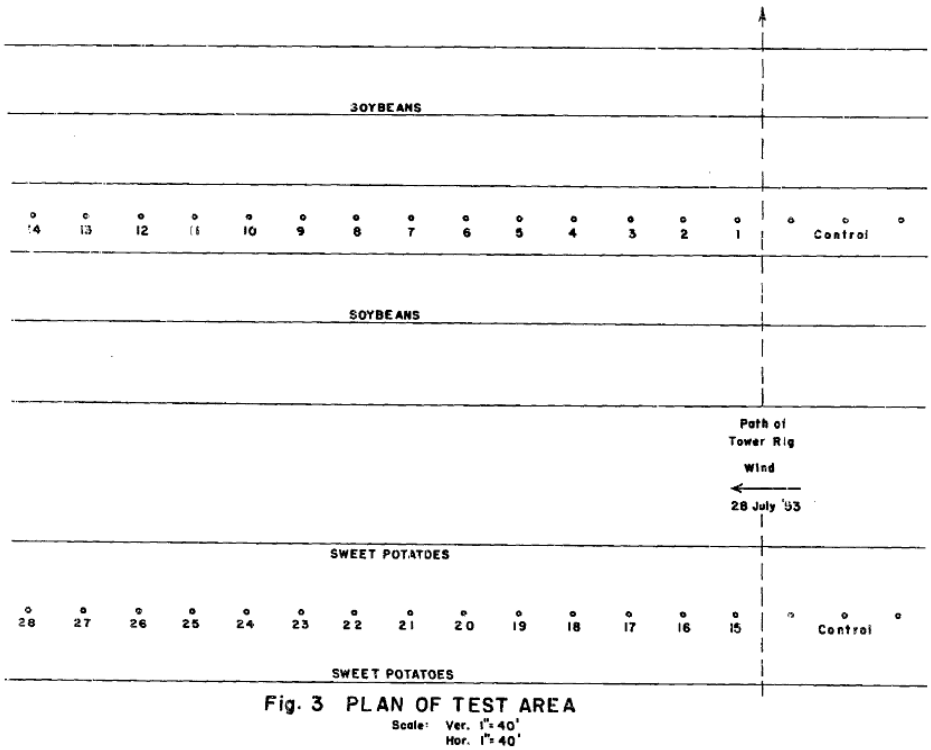

Figure 8 – *Plan of Test Area as reported in Special Report No. 201*[33]

2.9 Abstracts of Technical Publications April 1965-June 1965, July 1965, Technical Report 50, Defoliation Studies: Screening of Defoliants, Herbicides, and Desiccants

Copies of this report have been located at the Defense Technical Information Center (DTIC, AD0364884), however it remains classified as Confidential and was unavailable for review at the time of this preliminary investigation, but will be included in a subsequent version. Based on summaries of this report by others, it reports that from August 1961 to June 1963, Fort Detrick spray-tested 1410 compounds in the greenhouse to evaluate them as effective defoliants, and herbicides.

2.10 TM212 The Lateral and Vertical Movement of Four Herbicides Applied to a Grassland Soil – October 1970

In 1968, Fort Detrick began an investigation into the lateral and vertical movement of four herbicides through soil, including Agent Orange. Detrick conducted this experiment on 20 by 20-foot (i.e. 400 SF or 44.4 SY) test plots with a vegetative cover of Kentucky bluegrass and several species of broadleaf weeds. There were two Agent Orange plots both on a 3-5% slope, which differed by rate of agent applied, specifically 3 or 6 gallons per acre, applied in a liquid form with a hand-held sprayer. The Agent Orange was diluted with diesel fuel, so the rate of the Agent Orange and diesel fuel mix was at 28 and 56 gal/acre rate respectively. The plot applications occurred on 21 May 1968 and observations were made two months later. Residue samples were taken at various depths

six months and one year after the application. Residues of Agent Orange appeared in the samples taken. Based on the WWII era research on decomposition rates and bioassay of 2,4-D and 2,4,5-T, the researchers assumed the residue was composed primarily of 2,4,5-T. The test plots were on the "grid area" of Fort Detrick (i.e. Area B) but the specific location was not identified in the test report. Based on the reported application rate, the amount of Agent Orange used 7.32 ml (400 SF * 1 acre/43,560 SF * 3 gallons/acre * 128 ounces/ gallon * 29.57353 ml/ounce ***** 3 [1 a 3 gal/acre rate and 2 for 6 gal/acre rate]). As a 1:1 mix, this means 3.66 ml of 2,4,5-T was released for this experiment, which at a density of 1.8[34] roughly this equates to **approximately 11.99 grams of LN-974 were used for this test**.[35]

3 CONCLUSIONS AND REPORT LIMITATIONS

3.1 Conclusions

3.1.1 Total Estimated Amount of 2,4,5-T Agents Used

Camp Detrick conducted field plot experiments with plant inhibitors from 1944 through 1951 and published the results of this field work on a generally annual basis. The described field trials were not large scale tests but were smaller efforts involving test plots typically 6 by 18 feet in size, with the agent being tested applied with handheld sprayers. To prevent drift of spray, a movable light metal framed shelter with wind resistant cloth was used. The total amount of the 2,4,5-T compounds used for the years are approximated as:

- 911.92 grams plus an estimated additional 1,500 grams – 1944-45
- 2,620.17 grams – 1946-47
- 1,544.72 grams – 1948
- 76.18 grams – 1949
- 399.18 grams – 1950
- 460.87 grams – 1950-51

Fort Detrick used an additional approximately 118.28 grams of 2,4,5-T compounds in two subsequent field trials known to have occurred in 1953 and 1968, though as before the specific location on Fort Detrick is not confirmed.

This brings the total amount of 2,4,5-T compounds known to have been used at Fort Detrick is **approximately 6,131.32 grams with another 1,500 grams estimated to have been used in 1944-45. Therefore, a total estimate would be on the order of 7.63 Kilograms (Kg) or 16.82 pounds (**1 kilogram = 2.2046 pounds).

3.1.2 Locations

The test locations were identified as Fields A, B, C, D, E and F with three additional locations of plowed and unplowed grasses also used: Locations A, Location B and "the area to the northwest of Field B"). Two later tests also occurred, one in Area B, though the specific locations are not confirmed for either location. What is known about the specific areas:

Field A consisted of approximately 2 acres of Frankstown silt loam soil "located within the restricted areas and is 100 yards north of the C Division building". The soil classifications delimitation is based on the 1919 Soil Survey of Frederick County, Maryland (see Figure 1). This was one of the first fields used for small plot experiments and was in use in 1946, 1947 and 1950.[36] Approximately 489 grams of 2,4,5-T agents were used experiments on Field A. The "Restricted Area" boundary is depicted on

Figure 2 of this preliminary ASR and includes an undeveloped area (one with no buildings delineated) on the north end.

Field B consisted of approximately 3 acres of Athol gravelly loam soil "located near the northeastern corner of the Grid area". It was one of the first three fields used for small plot experiments and was in use in 1946 and 1947.[37] Approximately 28 grams of 2,4,5-T agents were used in experiments on Field B. A few parcels of the northeast end of Area B (i.e. the Grid Area) appear to be in agricultural use in September-October 1947 based on crop rows discernable on imagery from that time.[38] The parcels exhibiting signs of disking and crop rows, as opposed to the unplowed fields surrounding them in Area B, include roughly 5 acres, 4 acres and 1/3 of an acre as delineated in gold on the aerial imagery on Figure 9 below. The delineation of these parcels area on recent imagery is provided on Figure 11.

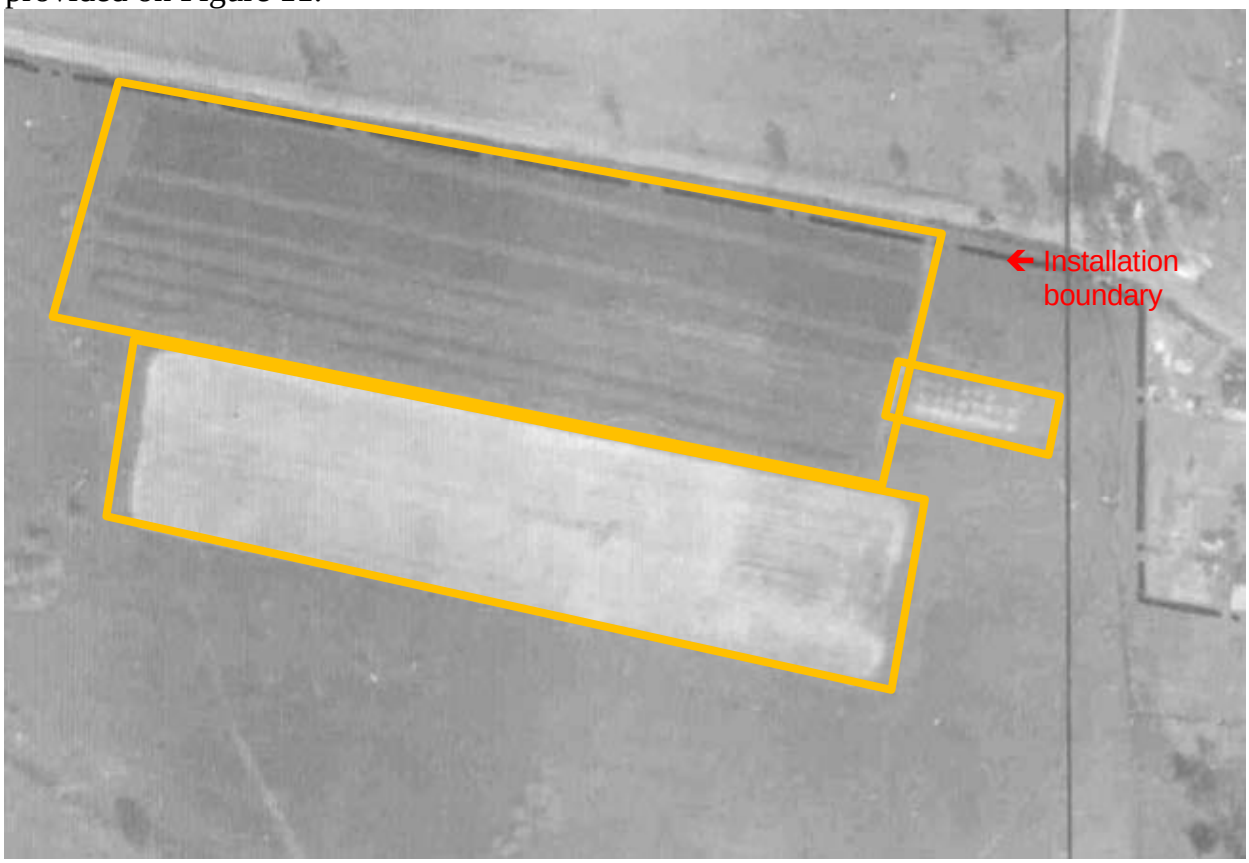

Figure 9 – *Northeast of Area B Aerial Imagery Sept.-Oct. 1947 - Field B Possible location.*[39]

Field C consisted of approximately 5 acres of Frankstown silt loam soil "located north of the coal trestle on the railroad". This was one of the first three fields used for small plot experiments and was first used in 1946 with continuing use in 1947, 1948, and 1949.[40] Approximately 2296 grams of 2,4,5-T agents were used experiments on Field C, the most of any of the Fields and at a cumulative rate per acre higher than the others as well (~459 grams/ acre). The probable location of Field C can be discerned based on the description and available aerial imagery from September-October 1947.[41] The Camp Detrick rail

lines run along the southwest and northwest perimeter of the Camp at the time, with a probable coal trestle identified on site plan (see Figure 2). The only areas north of the rail line are outside the boundaries of Camp Detrick at the time (but within the boundaries of current Fort Detrick Area A). Of particular note is a tract roughly 150 by 575 feet, that includes multiple varieties of small crop plots readily visible immediately north of the installation boundary. The mini-plots are no bigger than 32 by 75-feet, with many appearing to have multi-crops growing within them. Such varied planting would be highly atypical of a farmer but is exactly the variety expected for the test series described at Camp Detrick. This multi-crop parcel appears to be part of a parcel immediately to the northwest, which as a whole is approximately 5.7 acres, correlating to the size noted for Field C (see Figure 10 below). The roughly 5 acre tract to west of this Field C corresponds to Field D as described subsequently. The delineation of these areas on recent imagery is provided on Figure 11.

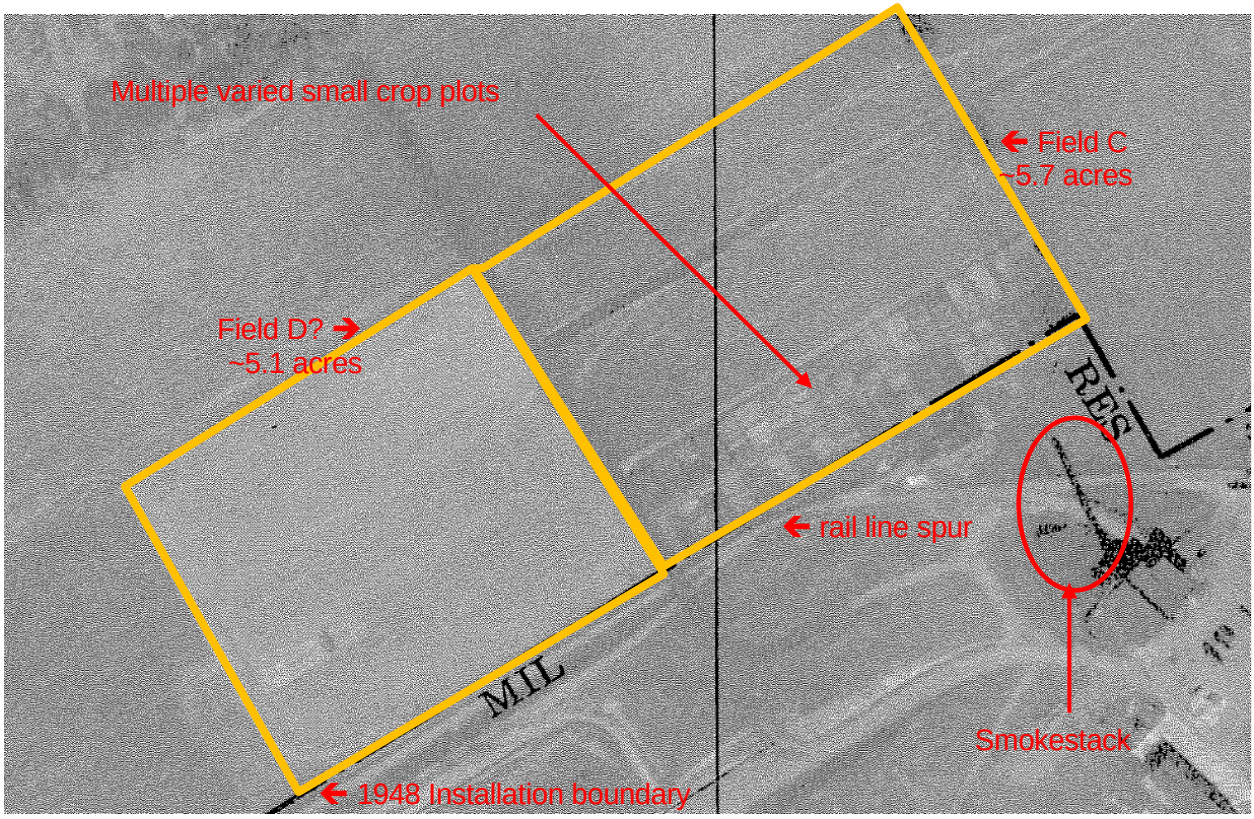

Figure 10 – *North of Coal Trestle in Camp Detrick Cantonment (Restricted Area) Aerial Imagery Sept.-Oct. 1947 - Field C and D – Probable locations.*[42]

Field D consisted of about 4 acres of Frankstown silt loam soil located "adjacent to and west of Field C". It was one of the fields used for small plot experiments with use beginning in 1948 and continuing in 1949 and 1950.[43] Approximately 1,307.5 grams of 2,4,5-T agents were used experiments on Field D, the second most of any of the Fields and at a cumulative rate per acre second highest as well (~327 grams/ acre). The probable location of Field D can be discerned on based on the description and aerial imagery from September-October 1947 (see Figure 10 above). The delineation of this area on recent imagery is provided on Figure 11.

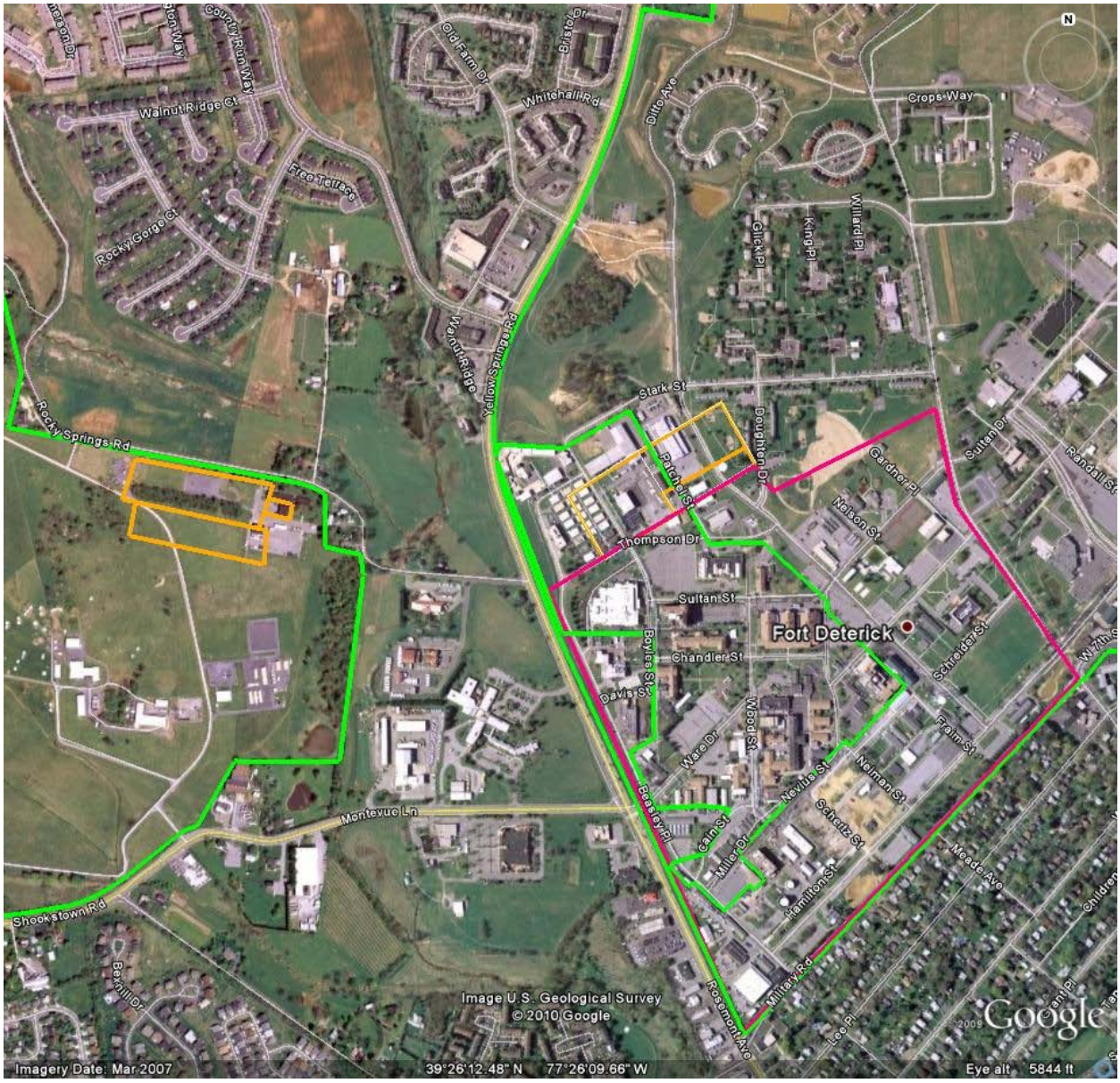

Figure 11 – *Aerial Imagery of Fort Detrick – March 2007*
Note: parcels in agricultural production in 1947 on Area B and probable Field C and D locations delineated in gold, current garrison boundary in green and WWII era cantonment area in red.

Field E consisted of about 6 acres of "Frankstown very fine sandy loam soil to Frankstown silty clay loam" soil "located approximately 1,400 feet northwest of the Commanding Officer's Quarters". It was one of the fields used for small plot experiments with use beginning in 1948 and continuing in 1949 and 1950.[44] Approximately 84.0 grams of 2,4,5-T agents were used experiments on Field E. Location of Commander's Quarter's in 1948 has not been confirmed as of yet.

Field F consisted of 16 acres of "Duffield silt loam" soil located "in the northern-most area of Camp Detrick" and used for small plot experiments beginning in 1950-51. It had been pasture prior to fall 1949, when it was plowed. In 1950, it was plated with cowpeas and plowed in September to be partially planted in rye and winter wheat the next month. In spring 1951, the remainder planted in spring oats and broadleaf crops.[45] Approximately 461 grams of 2,4,5-T agents were used experiments on Field F. The "Duffield silt loam" is not a soil classification on the 1919 Soil Survey of Frederick County, Maryland (see Figure 1) but represents a reclassification or refinement of the 1919 Frankstown soil type based on comparison with recent soil survey maps.[46]

Two additional locations of were used in 1948 for a single test of Vegetation Control of Unplowed Areas: Locations A & B, 115 feet north and 570 feet east of Field C, respectively. There were six 9 by 9-foot test plots used in Location A, which had broadleaf and annual grasses and 26 plots in Location B which had Kentucky bluegrass.[47]

Another "area to the northwest of Field B" was used to observe the effectiveness of LN agents during one test in 1947.[48]

3.1.3 Comparison to Domestic Uses of the Time Period

It is beyond the scope of this investigation to determine historic testing and use of 2,4,5-T herbicides by the military at other locations not on Detrick, within other government agencies (unless conducted at Detrick), at State universities and agricultural experiment stations or in the general agricultural practices of the period. However, it is worth placing the use and testing of 2,4,5-T at Detrick in context among general use in the United States. In 1971, the USDA reported on the domestic use of 2,4,5-T noting: *"About 3.4 million acres of farmland and 4.5 million acres of nonfarmland were treated with an estimated 8.9 million pounds of the phenoxy herbicide 2, 4, 5-T in 1969."* The report further stated that in 1969 (see Figure 12), farm use rates averaged from .24 to 2 lbs per acres with a total farm use average of 0.48 lbs per acres (ex.: 100 acres farm would use 48 lbs in one year).[49]

Appendix table 1.--Cost of 2,4,5-T and application, all domestic uses, United States, 1969

Use category	Acres treated	Materials: Pounds per acre	Materials: Cost per pound	Materials: Total cost	Application: Cost per acre	Application: Total cost	Total cost of material and application
	1,000 acres	Pounds	Dollars	1,000 dollars	Dollars	1,000 dollars	1,000 dollars
Farm use:							
Hay, pasture, and rangeland	2,441	0.24	2.75	1,611	1.00	2,441	4,052
Other crops	671	1/.59	2.75	1,093	1.00	671	1,764
Other farm use	339	2.00	2.75	1,865	1.00	339	2,204
Total farm use	3,451	.48	2.75	4,569	1.00	3,451	8,020
Nonfarm use:							
Federal Government	296	2.22	2.75	1,807	5.00	1,480	3,287
Lawn and turf	1,200	.50	2.75	1,650	1.00	1,200	2,850
Rights-of-way	2,175	2.01	2.75	12,022	10.00	21,750	33,772
Private nonfarm forests	430	2.07	2.75	2,448	3.00	1,290	3,738
Aquatic areas	81	2.00	2.75	446	2.00	162	608
Other uses	306	1.91	2.75	1,607	2.00	612	2,219
Total nonfarm use	4,488	1.62	2.75	19,980	5.90	26,494	46,474
Total all uses	7,939	1.12	2.75	24,549	3.77	29,945	54,494

1/ Calculated weighted average of individual crops and crop groupings (0.59233).

13

Figure 12 – *USDA reporting of Costs of 2,4,5-T and application, all domestic use, United States 1969*[50]

3.2 Preliminary ASR Limitations

3.2.1 General

The investigation does not represent a comprehensive research effort regarding the subject topic or property, as it was limited by time and what was able to be accomplished. In addition to the specifically cited relevant report noted in Section 2 that have not been acquired to date, there are other data and information gaps that will hopefully be filled in the coming months regarding additional textual, cartographic and aerial images, which should provide a clearer picture regarding likely and specific locations of 2,4,5-T use at Fort Detrick.

3.2.2 Research Limitations

Research was essentially limited to reports available through the Defense Technical Information Center (DTIC) and the Chemical, Biological, Radiological, Nuclear Information Analysis Center (CBRNIAC). Only a fraction of the total Fort Detrick related reports have been acquired to date. There are many other formal reports available from these sources that will be acquired, including classified ones. Furthermore, only a limited amount of records have been reviewed at the National Archives and Records Administration (NARA) College Park, MD facilities, although research trips are planned there in the coming weeks along with planned research at numerous other military, local, state or regional archives and records repositories. The ASR research plan is available upon request.

3.2.3 Site Plans and Cartographic Material

The Engineering Drawing/Blueprint Vault in Building 201 at Fort Detrick, Directorate of Information Services (DIS) has hundreds of drawers of material which need to be systematically reviewed for relevant site plans over time, which will provide a much clearer depiction of what areas were in use when and how. Included in this material are historic aerial images prints of Fort Detrick and cans of aerial film for 1972-11-16 at 1:12,800 scale and 1982-07-21 at 1:13,750 scale. The aerial images from the vault, as well as imagery from other archival sources will supplement the ability to define crop test locations. Based on the references cited on the Army Map Service (AMS) aerial photo map of 1948, there should be some Sep-Oct 1947 imagery. The previous Fort Detrick historic aerial photo analysis done by the EPA in 2001 concentrated only on Area B with imagery starting in 1952 and did not include the main post of Area A.

3.2.4 Auxiliary Documentation Regarding 2,4,5-T

This investigation has not uncovered any documentation specifying how or where the agent solutions were prepared at Fort Detrick, where the residual or surplus agent solutions were disposed of, or how and where test apparatus was cleaned between tests. Documentation regarding these matters, such as Standard Operating Procedures (SOP), would typically be found within installation correspondence records that are part of the planned research at NARA. Additionally, there should be interim reports and/or labs notebooks prepared prior to the Special Reports cited, which were a compilation summary of the plant inhibitor work. Locating this material would further document the use of 2,4,5-T at Camp Detrick, and would augment the documents found to date.

3.2.5 Real Estate

A complete review of the real estate history has not been completed to ascertain when the Army acquired each part of the installation either by lease, in fee or by some other real estate agreement to determine what parts of the property were available for use and at what times. According to the Public Affairs office history, the original purchase in 1943 of the main cantonment area included only 154 acres (see Figure 2), with an additional 147 acres added to in September 1946. This conflicts with the 1948 depiction of the boundaries of on the AMS aerial photomap which does not include that additional area. That history also notes that in September 1946, the 398 acres of Area B were added but cursory review of site plans in the installation drawing vault indicates Area B was acquired during WWII, perhaps under lease to be purchased in 1946. The 502.76 acres expansion of Detrick east of 7th Street did not happen until 1952.[51] Subsequently, the installation did out lease a number of these areas for agricultural use as well as a portion of Area B (see Figure 13 next page).

Figure 13 – *Fort Detrick with Out Leased Areas Cross Hatched – 10 September 1963*[52]

APPENDIX A

SAMPLE CALCULATION

A SAMPLE CALCULATION

With Special Report No. 92 covering the 1946 and 1947 Seasons[53], C Division of Camp Detrick begin reporting on the testing procedures used for the field plot experiments with plant inhibitors in a fairly regular manner, which is generally followed in subsequent iterations of the Special Reports from 1948 through 1952 (Special Reports Nos. 105, 130, 153 and 156). The purpose of Special Reports is not to report on the total amounts of agents used and as such it is not clearly stated how much is used and it must be calculated based on the information provided. Using the first test of 2,4,5-T agent in report No. 92 as example (i.e. section 2.3.3 Volume-Concentration Spray Studies, 1946 Experiment 1), the Material and Methods section includes the general test parameters (see Extract, Figure 14 below).

IV TOP APPLICATION STUDIES

A. Volume-Concentration Spray Studies.

1. Objective:

Certain greenhouse studies carried out at Camp Detrick during the war indicated that the same quantity of 2,4-dichlorophenoxyacetic acid produces varying degrees of inhibition when applied in different volumes of spray. With improved spray equipment available for static field applications, these experiments were designed to test the influence of volume of spray upon the growth inhibiting qualities of various sprays as measured by the yield of crop plants grown to maturity under field conditions.

2. 1946: Experiment 1.

(a) Materials and Methods:

Location: Field A
Test plant: Irish potatoes. Variety: Irish Cobbler
Date planted: 3 April 1946 Planting rate: "seed" pieces 12" apart, rows 3' apart.
Experimental design: Randomized complete block (4 reps)
Plot size: 12' x 15' (3 rows 15' long, treated)
Date treated: 29 May 1946 Stage: bud stage (1 lb. tubers/plot)
Weather conditions at time of treatment: Fair sky, no rainfall for several days.
Date harvested: 26 and 27 July 1946
Area harvested: 3 rows 15' long (9' x 15')
Preparation of solutions: See III, B.
Special technique in spraying: Each solution was applied uniformly to plots (15 sq. yds.) with a modified atomizer spray gun (fig. 1) operated under 10 or 20 lbs. constant air pressure from an oxygen cylinder (1800 lb. capacity) for the aqueous and oil sprays, respectively. The plots were protected from the effect of wind during the spray operation with canvas-covered shields 4 ft. high. Due to the extremely fine atomization produced by the spray apparatus, some drift of spray over the protecting screens was noted. Subsequent injury to the buffer rows, however, was only slight.

***Figure 14** – Extract Material and Methods – Special Report No. 92, Volume-Concentration Spray Studies, 1946 Experiment 1.*[54]

The Plot Size is "12' x15'" or rather 12 by 15-foot. This equates to 12 feet* 15 feet = 180 Square Feet (SF) or 20 Square Yards (SY) per test plot based on 1 SY equaling 9 SF (1 yard/3 feet * 1 yard/3 feet). There are "4 reps" meaning four replicates[v] or specifically that the test plot was repeated four times, for a total of 80 SY (4 reps * 20 SY).

In this test, two 2,4,5-T agents are being tested, LN-14 and LN-14 (TEA) (Triethanolamine 2,4,5-Trichlorophenoxyacetate) in two concentrations of compound applied per SY in grams: 0.1 and 0.5 grams per SY as noted below (see Extract, Figure 15 below).

Composition of materials applied:

Chemical	Solvent	Carrier	% Chemical	Total vol per sq yd(ml)	Compound per sq. yd. (g)
2,4,5-trichlorophenoxy-acetate	TBP*	#2 fuel oil	0.4	25	0.1
			1.0	10	0.1
			2.0	5	0.1
			2.0	25	0.5
			5.0	10	0.5
			10.0	5	0.5
triethanolamine 2,4,5-trichlorophenoxyacetate	TEA**	water	0.4	25	0.1
			1.0	10	0.1
			2.0	5	0.1
			2.0	25	0.5
			5.0	10	0.5
			10.0	5	0.5
tributylphosphate (control)		#2 fuel oil	0.8	25	--
			2.0	10	--
			4.0	5	--
			4.0	25	--
			10.0	10	--
			20.0	5	--

* tributylphosphate
** triethanolamine

Figure 15 – *Extract Composition of Materials Applied – Special Report No. 92, Volume-Concentration Spray Studies, 1946 Experiment 1*[55]

Perhaps confusing this, is that the agent is not in a pure form but diluted in a solvent or carrier to assist with distribution and that three different volumes of spray are tried (5, 10, 25 ml/SY). This necessitates the % chemical being sprayed to be different. However, since the goal of this exercise is to only determine the amount of agent applied, it is

[v] On occasion the replicates are described as "split plot", which could be interpreted that the test occurred on one test plot, with the replicates coming from four quadrants on one plot. Since the weights of the crops recovered are reported by replicate, with a mean value reported, the value of the four quadrant approach does not make sense over weighing the whole plot and dividing by four. Therefore, the replicates are interpreted to mean four separate plots of the stated size.

important only to note that concentration of 0.1 and 0.5 grams per SY were tried three different times:

0.1 grams/SY * 3 tests *20 SY test plot*four replicates = 24 grams
0.5 grams/SY * 3 tests *20 SY test plot*four replicates = 120 grams

Or 144 grams total for agent LN-14 and the same amount of approximately 144 grams of agent LN-14 TEA, for this test.

On occasion the test application rates are noted as occurring in pounds of agent applied per acre, which would be the more common agricultural way of expressing application rates. In these instances, the amounts are converted to a rate of compound applied in grams per square yard using a conversion factor of 0.093717432 is used to convert lbs/acre to grams/SY, based on 1 SY = 0.00020661157 acres and 1 pound = 453.59237 grams.

Another conversion is required when the application rate is announced in a volume dispersed per SY (i.e. ml per square yard) as opposed to a weight. In this case, the rate is converted to grams using a density of 2,4,5-T = 1.803 g/cm^3 (20 Celsius) and a 1 cm^3 = 1ml[56].

APPENDIX B

REFERENCES

B REFERENCES

The following list of references only represents the items cited in preparation of this report and do not illustrate all the documents reviewed or copied for the backup files.

[1] 1971-12-01 Joint CB Data Source Book Volume VII Antiplant Agents Part One Agent LNX CB-001596.pdf

[2] 1950-12-31 Quarterly Technical Report of Crops Division

[3] 1950-09-30 Quarterly Technical Report of Crops Division

[4] 1950-12-31 Quarterly Technical Report of Crops Division

[5] 1948-09-30 Quarterly Technical Report of C Division
1948-12-31 Quarterly Technical Report of C Division

[6] 1950-09-30 Quarterly Technical Report of Crops Division

[7] 1971-12-01 Joint CB Data Source Book Volume VII Antiplant Agents Part One Agent LNX CB-001596.pdf

[8] 1964-06-01 TR046 Calibration of Spray Systems C-123 MC-1, H-34 HIDAL, and A1-H FIDAL CB-128193.pdf

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