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OCONUS DEFOLIATION TEST PROGRAM

Semiannual Report

1 APRIL to 30 SEPTEMBER 1964

Sponsored by

Advanced Research Projects Agency

Remote Area Conflict Office

ARPA Order No. 423

U. S. Army Biological Laboratories

Fort Detrick, Maryland

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SYNOPSIS

(U) A test program of aerial spray applications with "purple", "pink" and a group of 8 defoliants, desiccants, and herbicides was initiated in early April 1964 on two test sites on the Pranburi Military Reservation to evaluate effectiveness of these chemicals on a mixed forest of broadleaf evergreens and deciduous trees representative of Southeast Asian vegetation.

(U) Applications were made with a twin-engine Beechcraft (C-45) equipped with a spray distribution system including a 32-foot boom with Tee Jet nozzles under wings and fuselage and an airdriven pump. Duplicate 10-acre plots were treated with each chemical mixture using three 100-ft. swaths per plot flown at a height of 30 to 50 ft. above treetops.

(U) "Purple" and its component 2,4,5-T butyl esters ("pink") were applied at 3 to 5 deposit rates and volumes in applications of pure chemical or in mixture with diesel fuel in dry season (April-May) and rainy season (August-September) tests. A group of 8 other chemicals in water or oil solutions was applied at two rates each during the rainy season (May-July).

(U) Evaluations of vegetation response to chemical treatments were made at periodic intervals by four methods: (1) changes in vertical visibility by a photographic technique; (2) changes in horizontal visibility by a target obscuration technique; (3) overall vegetation and species response as defoliation in reference to an initial vegetation inventory in each test plot; and (4) changes recorded in vertical aerial photographs of test plots.

(U) Preliminary observations of defoliation response indicate that:

(1) Application of "purple" and "pink" gave defoliation superior to that of other chemicals tested in observations made 4 months after treatment.

(2) "Purple" at rates as low as 1.2 gallons/acre gave effective defoliation (70-85%) as evaluated 4 months after treatment. Moderate defoliation (30-60%) occurred one month after treatment with "purple" at 2.5 to 3.5 gallons/acre during the rainy season.

(3) Diquat (4 lbs/acre), cacodylic acid (7 lbs/acre) and dicamba amine (7 lbs/acre) gave moderate defoliation response (30-50%) one month after treatment. These were the only active defoliants of the group tested.

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A. INTRODUCTION (U)

(U) This report outlines progress of a testing program of chemical defoliants conducted in Thailand by the U. S. Army Biological Laboratories at the request of the Advanced Research Projects Agency under Order No. 423.

(U) Objectives of the test program are: (1) to determine minimal rates and volumes of "purple" and component 2,4,5-T butyl esters ("pink") applied at different seasons of the year for effective defoliation and control of representative vegetation of Southeast Asia, and (2) to evaluate the effectiveness of other selected defoliants, desiccants and herbicides applied singly or in combination mixtures at different seasons of the year on representative vegetation of Southeast Asia.

(U) The test program is conducted in collaboration with the Military Research and Development Center of Thailand and its U. S. component, ARPA R & D Field Unit (Thailand).

B. BACKGROUND (U)

(U) Test site locations were established at the Pranburi Military Reservation with the assistance of MRDC officials. Arrangements were made with governmental authorities to use the facilities of the Ministry of Communications Airport at Hua Hin as a base of operations for the twin engine Beechcraft used for test applications. Survey and preparations of two test sites were initiated in August 1963. Lanes were cleared to mark boundaries of a series of 10-acre test plots for a total of 1450 and 2000 acres of treatments at the two test site locations.

(U) A twin engine Beechcraft equipped with spray distribution system has been provided by Air America, Inc. under a general contract with ARPA R & D Field Unit (Thailand) under ARPA Order 483. The plane with full-time pilot and aircraft maintenance service was made available in late December 1963. An intensive series of static flow tests and flight calibrations was made from January to March 1964 to secure suitable boom configurations for deposit of various spray volumes and chemicals.

(U) By 1 April 1964, the beginning of the report period, test site preparations and equipment calibrations were completed sufficiently that treatments and subsequent evaluations could be initiated.

C. TEST SITES (U)

(U) Two test sites (designated as No. 1 and No. 2) are located on the Pranburi Military Reservation at road distances of approximately 25 to 30 miles from Hua Hin Airport, used as a base of operational flights.

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1. Test Site No. 1 (U)

(U) Test Site No. 1 occupies a broad valley bordered at the west and partially at the east by precipitous mountain ranges which rise 300 to 1500 feet in elevation above the valley. The test site area to include a possible 1400 acres of treatment plots is approximately 1 mile wide and 3 miles long. The vegetation cover consists essentially of a dense upland forest of mixed broadleaf evergreen and deciduous trees ranging in height from 30 to 120 feet.

(U) In structure, the vegetation on Test Site No. 1 consists of a 2 or 3 storied forest with scattered large deciduous trees overtopping the main canopy level. The upper canopy includes Dialium indum, Koompassia excelsa, Lagerstroemia balansae, Lagerstroemia loudonii, Millettia sp., Spondias pinnata and Manilkara hexandra. The principal canopy is made up of broadleaf evergreen species including Diospyros mollis, L. Rhodocalyx, Euphorbia trigona, Hydnocarpus ilicifolius, Memecylon floribundum, Wiebuhria siamensis, Sindora siritina, Streblus asper, Streblus toxoides, and Vitex pinnata. Underbrush and small tree components include Grewia sp., Xanthophyllum, Mitrephora sp. and Mitragyna sp. Streblus toxoides, a thorny leaved shrub or small tree, is abundant in the underbrush as tangled impenetrable thickets.

(U) Test Site No. 1 has been delineated into test plots by clearing 12 parallel access lanes oriented in an east-west direction and approximately 1500 feet apart. These lanes provide for demarcation of 120 possible treatment plots 300 x 1500 ft. in dimension, oriented in a N-S direction separated by 100 foot buffer stripe.

2. Test Site No. 2 (U)

(U) This test site occupies the area contiguous to the road leading northwest from Pranburi Military Reservation to the artillery range. Terrain is mostly level but is bounded on northwest corner by a small range of hills.

(U) The area is characterized by a second-growth upland, shrubby forest with scattered remnants of the original stand of deciduous and broadleaf evergreen trees.

(U) Vegetation in Test Site No. 2 consists principally of small trees and large thicket-type shrubs such as Streblus toxoides, Memecylon sp., Mitragyna sp., Grewia sp., Atalantia monophylla, Diospyros sp., Olea brachiata, and Xanthophyllum sp. Scattered large trees of Manilkara hexandra, Dialium indum, and Hydnocarpus ilicifolius overtop the general shrub and small tree canopy.

(U) Access lanes to test plots have been cleared parallel or at right angles to the principal road in the area. Approximately 60 10-acre plots are available in the portion of Test Site No. 2 now surveyed. Additional areas have been allocated for test purposes for a possible 2000 acres of treatments.

(U) Approximately 170 plant species have been identified from the two test sites. A preliminary list of species is included in the appendix.

D. CALIBRATION AND MODIFICATION OF AIRCRAFT SPRAY DISTRIBUTION SYSTEM (U)

(U) During the preceding quarter (January-March) flight calibrations were made on grids located at the Hua Hin Airport and the Pranburi Military Reservation using diesel oil and "purple" or "pink" and diesel fuel mixtures. Emphasis was given to securing a uniform spray deposit over an approximate 100 ft. swath. At the close of the preliminary calibration period on 11 March 1964—suitable deposition patterns were secured by employing 15° flaps during application in flights made 50 to 75 feet above tree top height at air speeds of 100 knots.

(U) Experience gained from several treatment applications indicated that the technique of employing 15° flaps during spray applications was unsuitable because of flying hazards over test site terrain and the damage by applied chemicals on the flap and wing surfaces of the aircraft.

(U) Further modifications of the boom system to secure suitable deposition patterns were conducted under the direction of George A. Roth, consultant, during the period 25 April to 12 May. These consisted of lowering the boom to reduce air stream effect from the air-driven pump and installation of nozzles under the fuselage to eliminate the bimodal deposit pattern secured with nozzle configuration on wing booms only. The booms were shortened to a total length of 32 feet including the under-fuselage section. Attachment of the boom was at a distance of 23 inches below the fuselage and 16 inches at the ends of the booms.

(U) Nozzle configurations developed in the calibration tests which provide suitable deposit rates of 1.0, 2.0, and 3.0 gallons per acre of purple and other mixtures in 100-ft. swaths are given in the accompanying chart (p. 5). Nozzles are spaced at 6-inch intervals except for 5 nozzles on either side of the fuselage center-line which are spaced at 3-inch intervals. Nine nozzle positions on either side of the center-line are fitted for placement at a 45° angle to the rear; the remaining nozzles are positioned horizontally or parallel to the wing surface.

(U) A spray distribution pattern showing desirable trapezoidal characteristics secured with the specified nozzle configurations is illustrated in Figure 1. A deposit rate of 2.0 gals/acre for a 100-ft. swath is indicated.

(U) Flight calibration tests have been conducted concurrently with plot treatment applications to confirm actual deposition rates for the various rates and volumes employed in scheduled treatments. Supplemental calibration tests with diesel fuel and purple-diesel fuel mixtures were conducted to obtain additional deposition pattern and rate data for various nozzle configurations. It was necessary to conduct test applications of most of the chemical mixtures other than "purple" and "pink" without prior calibration

Nozzle Configurations on Wing Booms for Deposits of 1, 2, and 3 gals/acre

TeeJet Nozzles at 6-inch spacings

6 = L6-56 nozzle
8 = D8-56 nozzle
0 = D10-56 nozzle
X = 3/16" check valve
o = nozzle not in use
| = fuselage center

Patterns recorded from center fuselage to wing tip

3.0 gals/acre

Lt. wing | X-o-X-o-X-8-8-6-6-o-X-X-o-X-X-o-o-o-o-o-0-o-X-o-o-8-o-X-o-X---------- 6

Rt. wing | X-o-X-o-X-8-8-6-6-o-o-o-X-o-o-X-X-X-o-X-X-0-o-o-X-o-8-o-o-o-X---------- 6

45 psi 100 knots airspeed 115 GPM flow rate

2.0 gals/acre

Lt. wing | X-X-X-o-X-o-o-o-X-o-o-o-o-o-X-X-o-o-o-o-o-0-o-o-o-o-o-o-o-o-6---------- 6

Rt. wing | X-X-X-o-X-o-o-o-X-o-o-o-o-o-o-o-o-o-o-X-X-0-o-o-o-o-o-o-o-o-o-6---------- 6

55 psi 100 knots airspeed 80 GPM flow rate

1.0 gal/acre

Lt. wing | X-o-o-o-X-o-o-o-0-o-o-o-o-o-o-X-o-o-o-o-o-o-o-o---------- 6

Rt. wing | o-o-o-o-X-o-o-o-X-o-o-o-o-o-o-0-o-o-o-o-o-o-X---------- 6

50 psi 100 knots airspeed 55 GPM flow rate

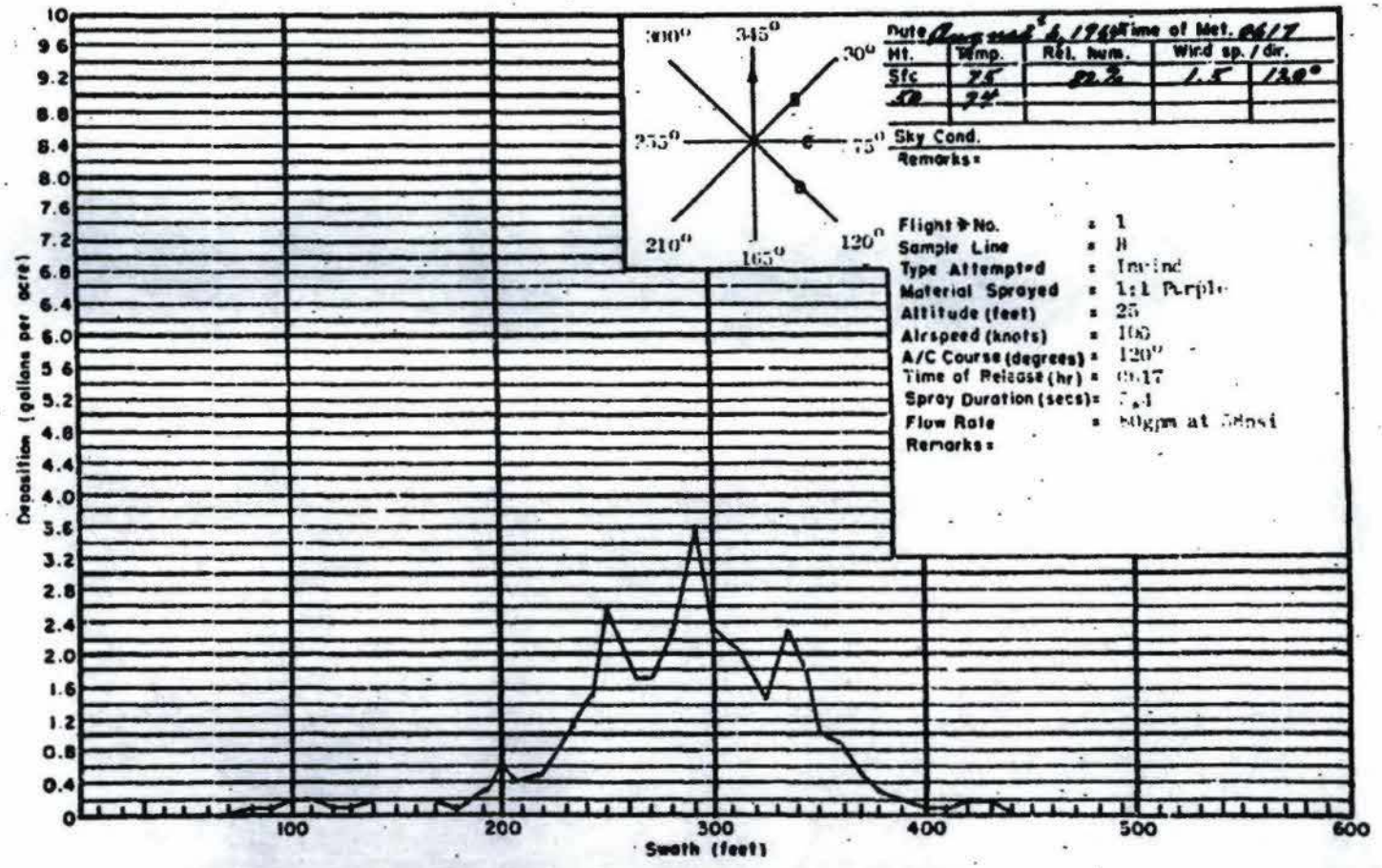

FIGURE 1. Spray deposit pattern. Deposit of 2.0 gals/acre on 100 ft. swath.

tests due to the limitations in supplies of these materials. Interpolations of nozzle configurations to obtain desired deposition rates of water solutions of defoliants and desiccants were made from previous data secured with diesel fuel & purple-diesel oil mixtures. At least one single and/or a triple flight was made on the calibration grid to secure deposition data at the time of all test applications.

(U) DuPont oil soluble red was used in diesel fuel mixtures and rhodamine blue in water solutions to secure colorimetric data on spray deposit rates on the calibration grid. Spray deposit patterns were obtained by the wet-plate acetone wash and spectrophotometric technique with grid station intervals of 10 feet. Calibration tests were continued to establish and verify suitable nozzle configurations to obtain deposition rates of 1, 2, and 3 gallons/acre of purple and pink and 1:1 dilutions with fuel oil. Deposition rates of these mixtures ranged from 75-85% of delivered volumes as shown by the calibration data.

(U) Calibration tests with water-soluble chemicals such as diquat and cacodylic acid showed approximately 50% of delivered volumes were recovered on the grid sampling stations. The greater rate of evaporation of water and consequent loss of small droplets accounts in large measure for the lower recovery rates with water solutions in contrast to that of the highly viscous "purple" or "pink" or diesel fuel mixtures with the latter chemicals.

(U) Calibration tests with diquat using aluminum plates showed highly variable results which were traced to reaction of the chemical on aluminum plates. Stainless steel plates were found to be superior in yielding repeatable results. Several sets of stainless steel plates were obtained for subsequent calibration tests. Grid lines have been replaced and renumbered facilitating more accurate evaluation of results.

E. METEOROLOGICAL OBSERVATIONS (U)

(U) Meteorological data have been secured at the calibration grid on the Pranburi Military Reservation and at temporary stations located in proximity to treated plots on the test sites.

(U) A portable 50-ft. telescoping tower stationed at the calibration grid is used to obtain the following data:

Wind speed and direction at 50 ft. height
Air temperature at 4 ft. and at 50 ft. height to determine inversion conditions
Relative humidity at 4 ft. height
Daily precipitation.

(U) Supplemental data on wind direction and velocity and precipitation are obtained at temporary meteorological stations established on access lanes in proximity to plots to be treated within a 1- to 2-week interval. These data provide information on actual conditions on the treatment plot at the time of application.

F. TEST PLOT PREPARATION AND MAINTENANCE (U)

(U) Work has continued during the 6-month period in establishing access lanes to treatment plots and camera station trails for evaluation. This work has employed a supervisor and 10-12 laborers in each of the test sites. Cutting of lanes and camera station trails has been essentially completed as of 30 September 1964. However, crews will be needed to maintain lanes and trails, to replace plot markers and camera site stakes and to install plot-marking flags as needed for treatment application.

(U) Figure 2 shows a diagram of typical plot layout between two access lanes 1500 ft. apart. The treatment plot is 300 ft. wide and 1500 ft. long allowing for three contiguous 100-ft. swaths 1500 ft. in length as indicated by the flight paths on the diagram. Camera station trails are established within the central 100 ft. swath to be treated in each plot. Camera station No. 1 is located 500 ft. from the access lane and a series of six stations established at 100 ft. intervals on an azimuth of 020° for 300 feet. The portion of the treatment plot selected for evaluation is within the central 500 ft. of plot length and the central 100 ft. of plot width to minimize effects of possible drift from adjacent plots.

G. TEST APPLICATIONS (U)

(U) Test applications of a group of rates and volumes of "purple" and "pink" were initiated on 2 April 1964. Intended rates of application included 1, 2, and 3 gallons/acre of "purple" and 1.5 gallons/acre of "pink" corresponding to the 2,4,5-T ester equivalent in the 3 gallon/acre rate of "purple". Dilutions with diesel fuel were made to test efficiency of low rates of the two chemicals.

(U) Test application data for this series of tests conducted in April and May and again in August-September are shown in Table 1. Applications were made on replicate 10-acre plots on Test Site No. 1 from April to 20 August. From 27 August to the end of September single replicates of each treatment were applied in each of the two test sites.

(U) Starting on 17 May 1964, a series of two rates for each of 8 selected defoliants, desiccants and herbicides was applied on replicate plots. Table 2 presents application data for this series conducted during the rainy season from mid May to 4 August. Attempted volume of spray deposit was 3 gallons per acre.

(U) Applications were made during early morning hours under inversion conditions to secure maximum rates of spray deposit of delivered chemical mixtures. One or two spray operators accompanied the pilot on all spray applications to secure data on delivered volume as determined by sight gauges on the hopper tank and to operate the spray control and pressure-regulating valves during flights.

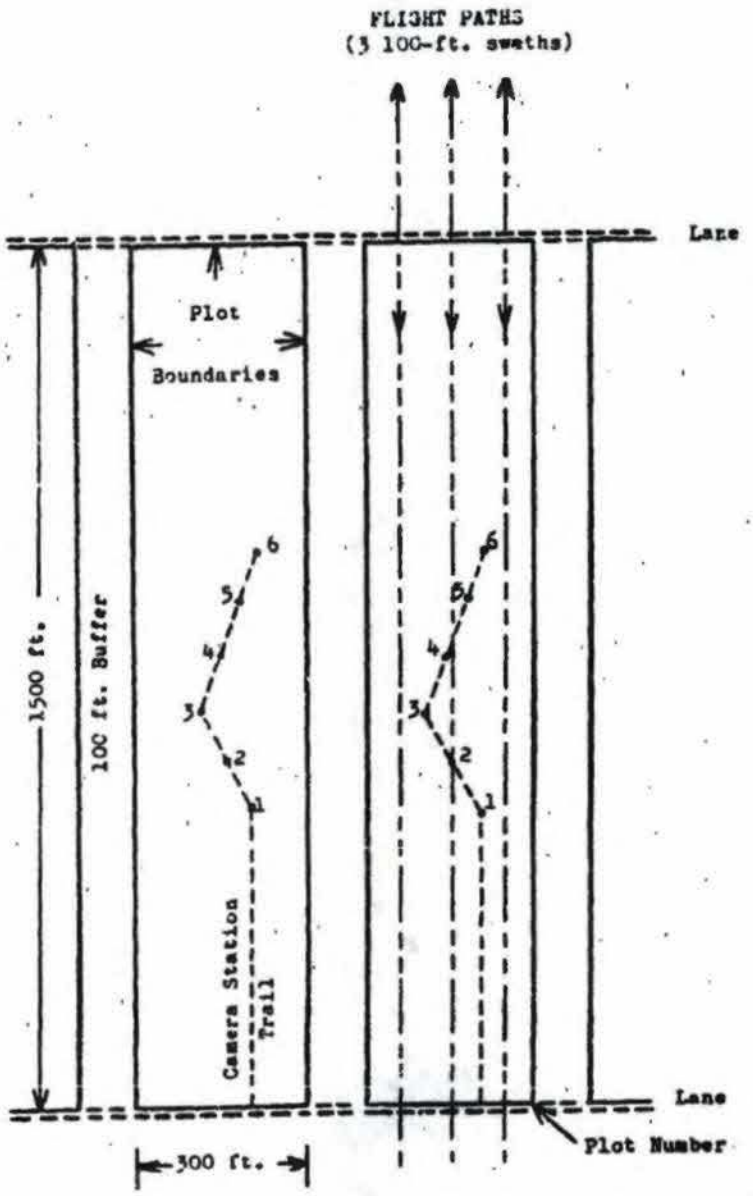

FIGURE 2. Plot detail showing camera stations and treatment pattern.

(U) The numbers of treatment applications made monthly were as follows:

April	7	July	8
May	6	August	7
June	3	September	7

Total: 38

H. VEGETATION INVENTORY (U)

(C) Prior to treatment each plot is inventoried by a crew of two or more Thai foresters from the vegetation teams under the direction of Lt. Col. Scheible's Environmental Research Group. Individual trees are coda-numbered by species along a 20- to 50-foot wide strip bordering the 500 ft. camera station trail between Stations 1 and 6. Records are made of the number of individuals and their relative position left or right of the camera station trail in each 100-foot segment of the 500 ft. belt. An attempt is made to mark a minimum of 5 to 10 individuals of all species encountered.

(U) In addition, location maps are made of all species in a circular plot of 30-foot radius at each of the six camera stations in each treatment plot.

(C) Herbarium collections have been made of all species encountered and identifications furnished by Mr. Tem Smitinand, Forest Botanist of the Royal Forestry Department. A preliminary list of woody plants on the two test sites is included in the appendix. Approximately 170 species of plants have been inventoried of which 35 to 50 are encountered frequently on the plot tallies.

(U) The 500-ft. belt with inventoried species is used in the evaluation of species response as described later in this report.

I. EVALUATION (U)

(U) Four methods of evaluation are being used to measure the effectiveness of test applications according to regular schedules.

1. Vertical photography (U)

(U) Improvement in vertical visibility is measured photographically at 6 camera stations in each treatment plot. Shutter exposures are chosen so that the sky is rendered dense black in the exposed negative while the forest cover is drastically underexposed, thus producing a silhouette of foliage and branch detail. Measurement of light transmittance through the negatives by means of a photoelectric cell with readings before and after treatment furnishes comparative data on vertical visibility changes based on original conditions.

(U) Two photographers working 5 to 6 days per week can photograph 30 to 35 plots per week. Negatives are shipped to Fort Detrick for evaluation by the photoelectric instrument or "defoliometer". The instrument is currently undergoing slight modification to permit greater accuracy under minimal light conditions. Data are not currently available for summarization.

(U) Schedule of evaluation by this technique is as follows:

Before treatment	1 month after treatment
2 days after treatment	2 months after treatment
5 days after treatment	3 months after treatment
1 week after treatment	4 months after treatment
2 weeks after treatment	5 months after treatment
3 weeks after treatment	6 months after treatment
	12 months after treatment

2. Horizontal visibility (U)

(U) This technique involves measurement of horizontal line-of-sight visibility on 8 lines radiating from one central point in each treatment plot. The target consists of a pole with three white discs (each with 25 dots) placed at 0.5, 1.2, and 1.9 meters above the ground. The target is moved out on each of 8 azimuth lines and readings of the number of dots visible taken at distances of 5, 10, 15, 20, 25 and 30 meters from a central station by means of binoculars. Each of the 25 dots per disc is given a 4% value for a total of 100% visibility and data averaged for each distance from the 8 lines.

(U) A 4-man team of local workers has been evaluating 25 plots per week under the supervision of a locally employed Filipino with an M.S. degree in Agronomy.

(U) Readings are taken at 1-, 2- and 3-week and at monthly intervals following treatment.

3. Vegetation Evaluation (U)

(U) Plant response records are taken on the vegetation inventory belts on the 500-ft. trail between camera stations in each plot. Data obtained consist of estimates of overall and individual species defoliation and chlorosis and eventual regrowth. Other important observations are made regarding plot layout, camera station position in relation to treatment area and possible spray drift or misapplication.

(U) The value of the vertical and horizontal visibility methods may depend much on records and interpolations obtained by visual observation.

(U) A schedule of observations similar to that of vertical photography is followed.

(U) Table 3 presents preliminary evaluation data secured by this method as discussed under Results.

4. Aerial Photography (U)

(U) Aerial photographs of test plots and test sites have been secured by means of a 35 mm camera mounted outside the door of the spray plane, facilitating vertical photography of plot areas. Both black-and-white and color photographs have been taken of selected treatments at frequent intervals.

J. RESULTS OF TEST APPLICATIONS (U)

(U) Preliminary data on overall vegetation response to treatment are shown in Table 3. Data are given in % defoliation on two duplicate plots for each treatment. A total of 38 treatments was made during this period. Results of two treatments will be included in a later report.

(U) Data at 4 months after dry season treatment with "purple" and "pink" show effective defoliation (70-85%) with "purple" at rates as low as 1.2 gallons/acre and of the component 2,4,5-T esters "pink" at 1.6 gallons/acre or as low as 0.8 gal/acre in a total volume of 2.5 gals/acre.

(U) Results after 1 month from rainy season applications of "purple" show moderate defoliation at 2.5 to 3.0 gallons per acre. Responses from "pink" were not as effective as "purple" in this period.

(U) Of the group of defoliants, desiccants and herbicides tested during May to July, diquat, cacodylic acid and dicamba amine showed moderate defoliation at 1 or 2 months following treatment. Evaluations taken at the 2- and 4-month intervals for diquat and cacodylic acid showed that regrowth had occurred following the initial defoliation effect.

(U) Butyne diol, tributyl phosphate, endothal salt, and merphos were not effective under the rates or conditions of the tests. The application with endothal acid can not be readily evaluated as a suitable cosolvent for the acid was not available at the time applications were made. Another test with proper formulation is planned.

TABLE 1. SPRAY DEPOSIT RATES AND VOLUMES OF TEST APPLICATIONS AT TEST SITES 1 AND 2 WITH PURPLE, PINK, AND DINOXOL, April - September 1964 [1]

TRTMT. NO.	DATE	PLOT NO.	CHEMICAL MIXTURE: CHEMICAL	SOLVENT	RATIO CH/SO	TOTAL DEPOSIT VOLUME GALS/A	DEPOSIT RATE: TOTAL ESTER [2] GALS/A	DEPOSIT RATE: ACTIVE INGRED. [3] LBS/A
	DRY SEASON							
1	2 Apr.	3 - 40 7 - 12W	Purple	—	—	1.2	1.2	10.3
2	5 Apr.	3 - 32 7- 20W	Purple	—	—	2.4	2.4	20.6
9	12 May	2 - 12 10 - 20	Purple	—	—	3.0	3.0	25.5
3	8 Apr.	3 - 48 7 - 4E	Purple	Diesel Fuel	1:2	2.6	0.9	7.4
7	25 Apr.	2 - 28 7 - 4W	Purple	Diesel Fuel	2:4	5.4	1.8	15.4
4	10 Apr.	2 - 52	Pink	—	—	1.6	1.6	14.2
5	12 Apr.	9 - 16 2 - 44	Pink	Diesel Fuel	1:1	1.8	0.9	8.0
6	21 Apr.	9 - 24 2 - 36	Pink	Diesel Fuel	1:2	2.5	0.8	7.4
8	8 May	9 - 8 2 - 20 10 - 32	Pink	Diesel Fuel	1:5	6.0	1.0	8.9

Continued

TABLE 1. SPRAY DEPOSIT RATES AND VOLUMES OF TEST APPLICATIONS AT TEST SITES 1 AND 2 WITH PURPLE, PINK, AND DINOXOL, April - September 1961. 1/ (Cont'd)

TRTMT. NO.	DATE	PLOT NO.	CHEMICAL MIXTURE CHEMICAL	SOLVENT	RATIO CH/SO	TOTAL DEPOSIT VOLUME GALS/A	DEPOSIT RATE TOTAL ESTER 2/ GALS/A	DEPOSIT RATE ACTIVE INGRED. 3/ LBS/A
	RAINY SEASON							
31	31 Aug.	B - 12N 6 - 28	Purple	—	—	2.5	2.5	20
30	27 Aug.	B - 4N 4 - 12	Purple	—	—	2.5 - 3.5	2.5 - 3.5	20 - 30
x	18 Aug.	3 - 20 5 - 48	Purple	Diesel Fuel	1:1	1.5	0.8	6.5
26	12 Aug.	1 - 52 5 - 40	Purple	Diesel Fuel	1:1	2.2	1.1	9.5
34	8 Sep.	B - 12S 8 - 0	Pink	—	—	1.0	1.0	8.9
29	20 Aug.	2 - 48 6 - 4	Pink	Diesel Fuel	1:1	1.1	0.6	4.9
27	13 Aug.	1 - 12 5 - 16	Pink	Diesel Fuel	1:1	1.8	0.9	8.0
35	14 Sep.	B - 20S 9 - 28	Dinoxol	—	—	1.0	0.6	4.0
36	18 Sep.	B - 28N 11 - 40	Dinoxol	—	—	2.5	1.6	10.0
37	21 Sep.	J - 4N 11 - 32	Dinoxol	Diesel Fuel	1:1	3.0	0.9	6.0

TABLE 1. (FOOTNOTES)

1/ Chemical Names for Designated Materials:

PURPLE: Mixture consisting of 50% N-Butyl Ester of 2,4-Dichlorophenoxyacetic acid, 30% N-Butyl Ester of 2,4,5-Trichlorophenoxyacetic acid, and 20% Iso-Butyl Ester of 2,4,5-Trichlorophenoxyacetic acid.

PINK: Mixture consisting of 60% N-Butyl Ester and 40% Iso-Butyl Ester of 2,4,5-Trichlorophenoxyacetic acid.

DINOXOL: Commercial formulation consisting of 31.6% Butoxy Ethanol Ester of 2,4-Dichlorophenoxyacetic acid and 30.3% Butoxy Ethanol Ester of 2,4,5-Trichlorophenoxyacetic acid.

2/ Deposit rate expresses as volume (Gals/Acre) of total ester.

3/ Deposit rate expressed in total acid content or acid equivalent in Lbs/Acre based on following acid equivalents:

Purple - 8.5 Lbs/Gallon

Pink - 8.9 Lbs/Gallon

Dinoxol - 4.0 Lbs/Gallon

TABLE 2. SPRAY DEPOSIT RATES AND VOLUMES OF TEST APPLICATIONS AT TEST SITE 1 WITH SELECTED DEFOLIANTS, DESICCANTS - HERBICIDES, May - July, 1964.

TRMT. NO.	DATE	PLOT NO.	CHEMICAL MIXTURE			TOTAL DEPOSIT VOLUME (GALS/A)	DEPOSIT RATE ACTIVE INGREDIENT (LBS/A)
			CHEMICAL	SOLVENT	RATIO CH/SO		
12	25 May	3 - 8 10 - 40	Butyne Diol 1/	Water	—	1.5	4.5
10	17 May	2 - 4 10 - 12	Butyne Diol	Water	—	1.5	6.0
11	22 May	3 - 6 5 - 32	Diquat	—	—	1.4	2.7
15	5 Jun.	1 - 32 6 - 16	Diquat	Water	2:1	3.0	4.0
14	3 Jun.	6 - 32 1 - 40	Cacodylic Acid	Water	—	2.5	5.0
13	30 May	2 - 24 6 - 40	Cacodylic Acid	Water	—	2.3	7.0
17	4 Jul.	1 - 16 3 - 36	Tributyl Phosphate	Diesel Fuel	1:1-1/2	3.8	6.0
16	18 Jun.	1 - 24 6 - 8	Tributyl Phosphate	—	—	3.2	12.0
19	17 Jul.	3 - 56 4 - 24	Endothal Acid	Water		1.2	1.0
18	15 Jul.	1 - 8 3 - 28	Endothal Acid	Water		2.6	3.3

Continued

TABLE 2. SPRAY DEPOSIT RATES AND VOLUMES OF TEST APPLICATIONS AT TEST SITE 1 WITH SELECTED DEFOLIANTS, DESICCANTS - HERBICIDES, May - July, 1964. (Cont'd)

TRMT. NO.	DATE	PLOT NO.	CHEMICAL MIXTURE			TOTAL DEPOSIT VOLUME (GALS/A)	DEPOSIT RATE ACTIVE INGREDIENT (LBS/A)
			CHEMICAL	SOLVENT	RATIO CH/SO		
21	22 Jul.	7 - 16W 9 - 12	Endothal Salt	Water	1:1	4.0	3.5
20	21 Jul.	4 - 40 6 - 36	Endothal Salt	--	--	2.7	5.0
23	28 Jul.	4 - 32 6 - 20	Dicamba Amine	Water	2:3	3.0	7.0
22	27 Jul.	1 - 36 5 - 8	Dicamba Amine	Water	3:1	3.4	15.0
25	4 Aug.	1 - 28 5 - 32	Merphos	Diesel Fuel	1:3	3.2	6.0
24	31 Jul.	1 - 36 5 - 8	Merphos	Diesel Fuel	2:3	4.0	12.0

TABLE 2. (FOOTNOTE)

1/ Chemical Names for Designated Compounds are as Follows:

Butynediol
2-Butyne-1,4-Diol; 95% active ingredient.

Diquat
1:1' Ethylene-2:2' dipyridylium cation; 2 lbs. active ingredient (cation) per gallon.

Cacodylic Acid
Dimethyl Arsinic Acid; 65% active ingredient.

Tributyl Phosphate
Tributyl Phosphate; 95% active ingredient.

Endothal Acid
3-6-Endoxohexahydrophthalic Acid; 100% active ingredient.

Endothal Salt
Disodium-3-6-endoxohexahydrophthalic Acid; 1.8 lbs. active ingredient per gallon.

Dicamba Amine
Dimethyl Amine Salt of 2-Methoxy-3,6-dichlorobenzoic - 6 lbs. acid equivalent per gallon.

Merphos
Tributyl Phosphorotrithioite; 7.2 lbs. active ingredient per gallon.

TABLE 3. PRELIMINARY RATINGS OF VEGETATION DEFOLIATION FROM TESTS APPLIED DURING DRY AND RAINY SEASONS, Apr-Sep. 1964.

CHEMICAL	RATE	TRMT. NO.	DATE	% DEFOLIATION 1 WK.	1 MO.	4 MO.
DRY SEASON	GALS/A					
Purple 100%	1.2	1	2 Apr.			60 - 80
Purple 100%	2.4	2	5 Apr.			85 - 80
Purple 100%	3.0	9	12 May			75 - 70
1:2 Purple/Oil	0.9	3	8 Apr.			65 - 40
1:2 Purple/Oil	1.8	7	25 Apr.			85 - 60
Pink 100%	1.6	4	10 Apr.			85 - 80
1:1 Pink/Oil	0.9	5	12 Apr.			75 - 70
1:2 Pink/Oil	0.8	6	21 Apr.			80 - 60
1:5 Pink/Oil	1.0	8	8 May			60 - 55
RAINY SEASON						
Purple 100%	2.5	31	31 Aug.	20 - 10	60	
Purple 100%	2.5 - 3.5	30	27 Aug.	10 - 10	50 - 30	
1:1 Purple/Oil	0.8	28	18 Aug.	10 - 10	25 - 25	
1:1 Purple/Oil	1.1	26	12 Aug.	15 - 15	35 - 25	
Pink 100%	1.0	34	8 Sep.	10 - 10	20 - 15 1/	
1:1 Pink/Oil	0.6	29	20 Aug.	10 - 10	20 - 15	
1:1 Pink/Oil	0.9	27	13 Aug.	10	30 - 30	

Continued

TABLE 3. PRELIMINARY RATINGS OF VEGETATION DEFOLIATION FROM TESTS APPLIED DURING DRY AND RAINY SEASONS, Apr-Sep. 1964. (Cont'd)

CHEMICAL	RATE	TRMT. NO.	DATE	% DEFOLIATION 1 WK.	1 MO.	4 MO.
RAINY SEASON	LBS/A				2 MOS.	
Butyne Diol	4.5	12	25 May			TR 2/ - 10
Butyne Diol	6.0	10	17 May			TR - 10
Diquat	2.7	11	22 May			TR - 10
Diquat	4.0	15	5 Jun.		35 - 50	10 - 10
Cacodylic Acid	5.0	14	3 Jun.		25 - 30	
Cacodylic Acid	7.0	13	30 May		30 - 50	- 15
Tributyl Phosphate	6.0	17	4 Jul.		10 - 10	
Tributyl Phosphate	12.0	16	18 Jun.		10 - 15	
					1 MO.	
Endothal Acid	1.0	19	17 Jul.		TR - 10	
Endothal Acid	3.3	18	15 Jul.		TR - 10	
Endothal Salt	3.5	21	22 Jul.		- - 10	
Endothal Salt	5.0	20	21 Jul.		TR - 10	
Dicamba Amine	7.0	23	28 Jul.		40 - 40	
Dicamba Amine	15.0	22	27 Jun.		40 - 45	
Merphos	6.0	25	4 Aug.	10 - 10	TR - 10	
Merphos	12.0	24	31 Jul.	10 - 10	0 - TR	

(Footnotes) 1/ % Defoliation at 3 weeks
2/ TR = Trace

APPENDIX A

PERSONNEL (U)

(U) Personnel from the U. S. Army Biological Laboratories and their task duties on the project during the report period included:

Dr. Robert A. Darrow, GS-14 1 April - 12 May
Project Leader, calibration, plot preparation evaluation.

Dr. George B. Truchelut, GS-12 1 April - 23 May
Asst. Project Leader, calibration, test application, evaluation.

Mr. Robert M. King, GS-9 1 April - 15 April
Taxonomist, vegetation inventory.

Mr. George A. Roth, Consultant 25 April - 13 May
Calibration, modification of spray distribution system.

Dr. Steve S. Szabo, GS-12 23 May - 12 September
Acting Project Leader, calibration, test application, evaluation.

1/Lt. Charles M. Bartlett 1 April - 16 June
Plot preparation, calibration, test application, evaluation.

SP-4 Walter J. Hart 1 April - 15 May
Calibration, meteorological observation, plot preparation.

Pfc. Glenn E. Trumble 1 April - 27 August
Calibration, plot preparation, test application, evaluation.

1/Lt. Loyd M. Wax 1 July - 30 September
Assistant and acting project leader, calibration, test application, plot preparation, evaluation.

Pfc. Arnold Hungerford 7 July - 30 September
Calibration, meteorological observations, test application, plot preparation, evaluation.

PRELIMINARY LIST OF PLANT SPECIES ON TEST SITES 1 AND 2

WOODY PLANTS

Acacia concinna	Leguminosae
Acacia sp.	Leguminosae
Achyranthes sp.	Amaranthaceae
Acronychia pedunculata	Rutaceae
Actephila sp.	Euphorbiaceae
Afzelia xylocarpa	Leguminosae
Albizzia sp.	Leguminosae
Alsomitra sp.	
Antidesma sp.	Euphorbiaceae
Aphania sp.	Sapindaceae
Artabotrys sp.	Annonaceae
Artocarpus sp.	Moraceae
Atalantia monophylla	Rutaceae
Atalantia roxburghiana	Rutaceae
Atalantia sp.	Rutaceae
Azadirachta indica	Meliaceae
Bambusa arundinacea	Graminae
Bambusa sp.	Graminae
Bauhinia sp.	Leguminosae
Bauhinia sp.	Leguminosae
Bauhinia sp.	Leguminosae
Bombax insigne	Malvaceae
Bridelia monoica	Euphorbiaceae

Bridelia siamensis	Euphorbiaceae
Buchanania sp. (Glabra)	Anacardiaceae
Buxus wallichiana	Buxaceae
Caesalpinia sp. (22)	Leguminosae
Caesalpinia sp. (23)	Leguminosae
Canangium latifolia (= Cananga)	Annonaceae
Capparis macropoda	Capparidaceae
Capparis thorelii	Capparidaceae
Capparis sp.	Capparidaceae
Casearia grewiifolia	Flacourtiaceae
Cassia sp.	Leguminosae
Celastrus sp.	Celastraceae
Celtis sp. ?	Ulmaceae
Cissus cf. discolor	Vitaceae
Cleistanthus sp.	Euphorbiaceae
Combretum procursum	Combretaceae
Combretum quadrangulare	Combretaceae
Connarus sp.	Connaraceae
Cordia sp.	Boraginaceae
Cratoxylum sp.	Hypericaceae
Croton sp. (33)	Euphorbiaceae
Croton sp. (58)	Euphorbiaceae
Dalbergia nigrescens	Leguminosae
Derris sp.	Leguminosae
Dialium indum	Leguminosae

Diospyros busifolia	Ebenaceae
Diospyros mollis	Ebenaceae
Diospyros montana	Ebenaceae
Diospyros rhodocalyx	Ebenaceae
Diospyros sp. (38)	Ebenaceae
Diospyros sp. (39)	Ebenaceae
Diospyros sp. (40)	Ebenaceae
Diospyros sp. (43)	Ebenaceae
Drypetes sp.	Euphorbiaceae
Ehretia laevis	Boraginaceae
Erythroxylum cuneatum	Erythroxylaceae
Erythrina sp.	Leguminosae
Euonymus sp. (31)	Celastraceae
Euonymus sp. (107)	Celastraceae
Euonymus sp. (144)	Celastraceae
Euonymus sp. (146)	Celastraceae
Euphorbia trigona	Euphorbiaceae
Ficus altissima	Moraceae
Ficus glabrilla	Moraceae
Ficus hispida	Moraceae
Ficus maclellandii	Moraceae
Ficus sp. (45)	Moraceae
Ficus sp. (155)	Moraceae
Flacourtia rukam	Flacourtiaceae
Gardenia collinsae	Rubiaceae
Garuga pinnata	Rubiaceae

Celonium multiflorum	Euphorbiaceae
Glycosmis pentaphylla	Rutaceae
Grewia sp. (35)	Tiliaceae
Grewia sp. (50)	Tiliaceae
Harrisonia perforata	Simaroubaceae
Hiptage marginata	Malpighiaceae
Holoptelea integrifolia	Ulmaceae
Hoya obcordata	Asclepiadaceae
Hydnocarpus ilicifolius	Flacourtiaceae
Hymenocardia sp.	Euphorbiaceae
Hymenodictyon excelsum	Rubiaceae
Hymenopyramis brachiata	Verbenaceae
Jasminum sp.	Oleaceae
Kaempferia sp.	
Koompassia excelsa	Moraceae
Lagerstroemia balansae	Lythraceae
Lagerstroemia loudonii	Lythraceae
Leptonurus sp.	Opiliaceae
Litsea sp.	Lauraceae
Luvunga scandens	
Mallotus sp.	Euphorbiaceae
Manilkara hexandra	Sapotaceae
Melia azedarach	Meliaceae
Memecylon floribundum	Rutaceae
Memecylon sp.	Melastomaceae
Micromelum hirsutum	Rutaceae

Miliusa levutina	Annonaceae
Millettia sp.	Leguminosae
Mitragyna brunonis	Rubiaceae
Mitrephora sp.	
Nicbuhria siamensis	Capparidaceae
Olea brachiata	Oleaceae
Opilia sp.	Opiliaceae
Ovaria sp.	Annonaceae
Pachygone dasycarpa	
Pakia javanica	
Pentace sp. (or Grewia sp.)	Tiliaceae
Phyllanthus sp. (78)	Euphorbiaceae
Phyllanthus sp. (101)	Euphorbiaceae
Phyllanthus sp. (137)	Euphorbiaceae
Phyllanthus sp. (154)	Euphorbiaceae
Polyalthia sp.	Annonaceae
Pterospermum diversifolium	Sterculiaceae
Randia sp. (139)	Rubiaceae
Randia sp. (160)	Rubiaceae
Rhaphis micrantha	Palmae
Rinorea sp. (Alsodeia)	Violaceae
Sapium insigne	Euphorbiaceae
Sauropus	Euphorbiaceae
Schyphellanda pienei	Violaceae
Semecarpus sp.	Anacardiaceae
Sindora siamensis	Leguminosae

Sphenodesma sp.	Verbenaceae
Spondias pinnata	Anacardiaceae
Stemona sp.	Stemonaceae
Sterculia foetida	Sterculiaceae
Sterculia sp. (89)	Sterculiaceae
Sterculia sp. (118)	Sterculiaceae
Stereospermum sp.	Bignoniaceae
Streblus asper	Urticaceae
Streblus toxoides	Urticaceae
Strychnos sp.	Loganiaceae
Symplocos sp. (125)	Symplocaceae
Symplocos sp. (135)	Symplocaceae
Syzygium cumini	Myrtaceae
Tarenna sp. (longifolia)	Rubiaceae
Terminalia tripteroid	Combretaceae
Terminalia sp.	Combretaceae
Terraea sp.	Miliaceae
Tetrameles nudiflora	Datiscaceae
Tetrastigma sp.	Rubiaceae
Vertilago calyculata	Rhamnaceae
Vitex limonifolia	Verbenaceae
Vitex pierrei	Verbenaceae
Vitex pinnata	Verbenaceae
Vitex quinata	Verbenaceae
Walsura trichostemon	Meliaceae
Xanthophyllum sp.	Rutaceae

Wrightia tomentosa	Apocynaceae
Ziziphus oenoplia	Rhamnaceae
Unknown (19)	Euphorbiaceae
Unknown (68)	
Unknown (139)	
Unknown (149)	Annonaceae
Unknown (150)	Annonaceae
Unknown (165)	Acanthaceae

GRASSES AND NONWOODY PLANTS

Aglaeonema sp.	Araceae
Digitaria sp.	Gramineae
Eupatorium odoratum	Compositae
Fimbristylis sp.	Cyperaceae
Imperata cylindrica	Gramineae