Uploaded to the VFC Website

▶▶ ▶▶ May 2014 ◀◀ ◀◀

This Document has been provided to you courtesy of Veterans-For-Change!

Feel free to pass to any veteran who might be able to use this information!

For thousands more files like this and hundreds of links to useful information, and hundreds of "Frequently Asked Questions, please go to:

Veterans-For-Change

Veterans-For-Change is a A 501(c)(3) Non-Profit Organizaton
Tax ID #27-3820181
CA Incorporation ID #3340400
CA Dept. of Charities ID #: CT-0190794

If Veterans don't help Veterans, who will?

We appreciate all donations to continue to provide information and services to Veterans and their families.

https://www.paypal.com/cgi-bin/webscr?cmd=_s-xclick&hosted_button_id=WGT2M5UTB9A78

Note: VFC is not liable for source information in this document, it is merely provided as a courtesy to our members & subscribers.

11901 Samuel, Garden Grove, CA 92840-2546

Item ID Number 04811 ☐ **Not Scanned**

Author Darrow, Robert A.

Corporate Author

Report/Article Title Typescript: Draft - Use of Herbicides on Southeast Asia

Journal/Book Title

Year 1967

Month/Day December

Color ☐

Number of Images 58

Descripton Notes

USE OF HERBICIDES IN SOUTHEAST ASIA

Received 12 Dec 67

Herbi costs & crit 8

DARROW, IRISH & MINARIK

20

Foreword

Because of the wide-scale use of herbicides in Southeast Asia, many questions have been raised in the last two years concerning the technical details of these agents, methods of dissemination, and concepts of employment. Much new information and field experience is now available to Chemical Officers. The information contained in these pages attempts to answer some of these questions.

It appears that rotation of military personnel or technical personnel within the Republic of Vietnam and Southeast Asia has been such that continuity of technical information tends to be interrupted. The questions that are asked of Chemical officers by personnel in Vietnam are very penetrating and show that they have received a great deal of thought. Often, Chemical officers have been hard put to answer these questions. Prior to departing on a Vietnam assignment, it would be helpful to Chemical officers to spend a week or two at Fort Detrick where many pertinent reports and documents are available in Crops Division and personnel are available there for discussion of problems that have arisen since 1961. In Vietnam, Chemical officers should take advantage of the Task 2 and Task 20 field files available at the Advance Research Projects Agency (ARPA) Research and Development Field Unit at 4A Bach Dang, Saigon, Vietnam. In addition, records and research reports are on file at the Chemical Division, J-3 Element, Combat Operations Center (MACCOC) Headquarters, United States Military Assistance Command, Vietnam, GIA Long Street, Saigon.

NOTE: PURPLE, PINK and BLUE (dry powder) have all been used but are no longer being procured. They are mentioned here in case some unused material is located some where in the country. Some of the drums with a PINK stripe have faded to white but these will have been in the country since 1961-62. PINK, ORANGE, and PURPLE have a distinctive similar odor that can aid in their identification if it becomes necessary.

Soil sterilants are described but have not yet (mid 1967) been procured in quantity for use in the country.

DRAFT

USE OF HERBICIDES IN SOUTHEAST ASIA

Section I. HERBICIDES, DESICCANTS, AND SOIL STERILANTS

A herbicide is any preparation used to kill or inhibit the growth of plants. The term includes defoliants, desiccants, plant growth regulators, and soil sterilants. The specific agents discussed herein are listed below:

Code or Trade Name	Compound
	HERBICIDES
PURPLE (obsolete)	Mixture consisting of 50% n-butyl ester of 2,4-dichlorophenoxyacetic acid (2,4-D) 30% n-butyl ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) 20% iso-butyl ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)
ORANGE	Mixture consisting of 50% n-butyl ester of 2,4-dichlorophenoxyacetic acid (2,4-D) 50% n-butyl ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)
PINK (obsolete)	Mixture consisting of 60% n-butyl ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) 40% iso-butyl ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)
WHITE (Tordon 101) (Use only if ORANGE not available.)	Commercial aqueous formulation consisting of: amine salt of 2,4-D 80% and amine salt of Picloram (4-amino-3,5,6-trichloropicolinic) acid 20%; 2.5 lbs/gal total active ingredient
	DESICCANTS
BLUE (Phytar 560 G)	Aqueous liquid formation consisting of Sodium cacodylate (the sodium salt of dimethyl arsenic acid) buffered to pH 7.0 plus a surfactant
BLUE (dry powder) (obsolete)	Spray dried formulation consisting of 65% cacodylic acid

Code or Trade Name	Compound
	SOIL STERILANTS
Hyvar-X (duPont)	Wettable powder consisting of 80% 5-bromo-3-sec butyl-6-methyl uracil 20% inert
Hyvar-X-WS (duPont)	Water soluble powder at 1.5 lbs/gal 50% 5-bromo-3-sec butyl-6-methyl uracil 50% inert
Urox 22 (Allied Chemical)	Granules consisting of 22% monuron trichloroacetate 88% inert

Tropical vegetation appears to be more resistant to herbicide sprays than are the temperate climate species found in the continental United States. This resistance of tropic vegetation has challenged the creative talents of scores of military and industrial plant physiologists, biochemists, formulators, and spray system designers for the last decade and a half. Little vegetation analysis and species identification has been done in Southeast Asia, and only one pioneering study has attempted to relate genera and species response to chemical application. A need exists both for quicker acting herbicides and for agents that will kill or defoliate a broader spectrum of tropic species at low concentrations.

Consider four groups of plant species: A, B, C, and D. "A: represents a group which is susceptible only to 2,4-D; "B" a group which is susceptible to both 2,4-D and 2,4,5-T; "C" a group that is susceptible only to 2,4,5-T; and "D" a group that is susceptible to neither agent. Most of the applications that have been made in the Republic of Vietnam have been made with mixtures (i.e., ORANGE or PURPLE) of these two chemicals and, consequently, most of our information refers to those species in groups A, B, and C without knowing specifically the A and C groups as far as the jungle species are concerned. A few studies have identified the regional plant species of military significance in Southeast Asia, but the vegetation tends to change significantly from North to South and East to West in the Southeastern Asia subcontinent, and the intelligent use of this precise information would necessitate some study of botany and plant taxonomy by the Chemical officer. As an alternative to this, a search is being conducted to discover herbicides with a broad kill range.

Rubber trees appear to be in Group B. In fact, rubber, cotton, melons, bananas, and a few other garden species are extremely sensitive to herbicides and may almost be considered "indicator" plants.

Inadvertent or improper use of herbicides in the vicinity of these plants will result in early and extensive damage with heavy indemnification of the civilian owners being expected.

After the initiation of large-scale defoliation missions by the Air Force in January of 1962, damage to rubber plantations was experienced and was made a matter of record. These records and estimates of damage can be found in the files of the original 202 committee in Saigon. It was concluded at that time that rubber was a species sensitive to a far greater degree than in any of the so-called jungle species appeared to be. In the first recorded case, as near as the facts available could be determined, it appeared that the injury to the young rubber trees occurred even though the plantation was located some 500 yards away and upwind of the target at the time of spray delivery. Subsequently, within one week, the plantation showed considerable leaf fall. It can only be conjectured that the damage to the rubber plantation was due to the known shift of wind direction from the target to the rubber plantation some 5 hours after spraying and that vapors of the chemical used (PURPLE) were strong enough in concentration to cause this injury to the rubber saplings. All of this is based, of course, on testimony of the spray pilot at the time that he did not make any spray passes or spray releases over the rubber plantation. The reason for the damage was not believed to be excessive winds or lapse conditions at spray time. It would appear to come from vaporization after the spray had settled on the vegetation. In regard to this aspect, there are hundreds of cases where roadside targets or canal spraying in mangrove swamp areas have been made where the upwind side of the spray swath is a markedly discreet line. This indicates that even though the mangrove species is fairly sensitive to herbicides (ORANGE and PURPLE), the vapors of the material are not necessarily suspect in causing damage beyond the sprayed area of mangrove. Otherwise, this upwind line of spray effect either would be ragged or would taper off.

However, there have occurred many instances where herbicidal sprays have been misdirected, or have been carried off-target by wind with damage resulting to areas of vegetation where damage was not desired. This can happen either from "mist drift" or from the presence of vapor concentrations in sufficiently high concentrations. It can also happen by equipment being flown over such an "off-target" area where equipment checks were made to "fill the boom" and/or before or after a mission where some nozzles were leaking.

The release of aerial sprays during the middle of the day is not only wasteful of material but is likely to cause damage almost anywhere but where it is intended. Releases under inversion conditions are recommended and where winds do not exceed 5 to 8 miles per hour. The appropriate calm inversion periods usually are dissipated after about 0800-0900 daily.

There are certain crop species that are very sensitive to these chemicals and 0.1 pound per acre could be a lethal dose for some of them (e.g., melon and tomato). One gallon of ORANGE contains 10.75 pounds of active ingredient, or about 100 times this lethal dose, and 0.1 pound per acre could be delivered very easily by one or more dripping nozzles from the aircraft. It is entirely possible that such a delivery could be made unknowingly and/or unintentionally.

ORANGE has essentially the same physical and biological characteristics and its predecessor PURPLE and behaves similarly with respect to spray drift and volatility.

Leaf fall may or may not be harmful to rubber trees. During the dry season in RVN, rubber trees normally shed their leaves. Research studies in Asia indicated rather conclusively that low dosages of 2,4-D stimulate latex flow. If defoliation of rubber plantations is due to vapors, it is inconceivable that the rubber trees received more than a very light dose. If the defoliation was due to drift of fine particles, the dose could have been much higher, but even trees that are completely defoliated may suffer no permanent damage and extremely careful inspection of the plantations should be made over a 6-week period before any indemnification is paid to the owners. In February of 1967, many Vietnamese rubber plantations were unthrifty due to lack of care, abundant undergrowth, lack of fertilization, and extensive insect damage (especially red spider), and the damage caused by these factors has been erroneously attributed to misuse of herbicides in Vietnamese and American spray missions.

Section II. SYMPTOMS OF PLANT INJURY FROM HERBICIDES

Upon application of militarily significant amounts of herbicides, most plants react in one or more of the following ways:

1. In some plants, leaves and growing stems form loops and coils or develop marked curvature.

2. Growing stems may remain green, but may swell, develop cracks, and form callous tissue.

3. Watery, translucent buds often appear at the crowns of some plants.

4. Spongy, enlarged roots may appear, turn black or grey, and rot.

5. Necrotic (dead) areas will form on the leaves wherever the spray droplets have impinged on the leaf surface. A ring of yellow or chlorotic tissue appears around the necrotic area, and gradually the entire leaf will develop yellow, red or brown autumnal coloration and fall.

Section III. LIMITATIONS OF HERBICIDES

Primary or virgin jungle areas that have multiple canopies of vegetation may require repeated sprayings to penetrate the various layers of the canopy.

Vegetation in dry areas will usually be more resistant than vegetation found in wet areas for at least part of the time they will be in a dormant condition. Herbicides are most effective when used during the growing season, usually during or immediately after the rainy season.

Herbicides now in use require time for translocation and metabolic disturbance in the plant and do not defoliate in a period of a few days. Thus, available herbicides have little value in surprise attacks except that the Viet Cong have been reluctant to be caught in a herbicidal spray or to enter a newly sprayed area. Maximum militarily effective defoliation (65 percent or more) in a jungle area usually requires 2 to 4 weeks. This lag time should be taken into consideration when planning herbicide missions.

When herbicides are sprayed from above the jungle canopy, there will be more herbicide delivered directly under the flight pattern with diminishing amounts delivered downwind from the line of flight. Air turbulence in wing tip or rotor tip vortices help the spray droplets penetrate the jungle canopy and, especially with helicopter applications at relatively low altitudes, a degree of spray aimability is noted. In areas where the jungle is very dense and numerous canopies of vegetation are found, a second application will not produce additional leaf fall until the effects of the first spraying has been achieved. Foliage which has received the first spray application and which has not fallen will intercept portions of the second spraying. With the herbicide ORANGE, a second spraying may be required for heaviest jungle about 4 weeks after the first spray mission.

The butyl esters of 2,4-D and 2,4,5-T are the most effective, but they are also volatile. The fumes may cause injury to nearby susceptible crops. Other forms of these chemicals, such as amine salts, are water soluble and non-volatile.

Section IV. ANALYSIS OF OPERATIONS

Some of the factors to be considered prior to spraying target vegetation are:

1. Analysis of the area:

   a. Types of vegetation (grasses or broadleaf types).

   b. Growth stages of the vegetation.

2. Proximity of susceptible crops to the target area.

3. Type of herbicide suitable for the target (depends upon the species of plants in the target area).

4. Time of effect and duration of effect.

5. Ecology of area. If broadleaf species (shrubs) are killed off, grasses come in and soon cover the ground previously occupied by the shrubs. It may then be necessary to kill the grass (with BLUE) if bare ground is desired.

Because herbicides are growth regulators that disrupt the metabolism of the growing plant, jungle vegetation and crops respond to herbicide treatments best during the most rapid growth period. This growth period will usually be from the time buds and new leaves are first visible until about 3 to 4 weeks before the beginning of the dry or dormant season. In tropical areas with a monsoon climate having a rainy and a dry season, rapid growth would occur during the rainy season and the use of the oil soluble agent, ORANGE, would be appropriate. Oily agents or those mixed with No. 2 Diesel fuel oil are not readily washed off the foliage. Depending upon the area in which herbicide operations are conducted, the period of most active growth will usually be about 6 months each year. In some tropical lowland areas, where a variety of species exist and water is plentiful and continuous growth exists, herbicides will be effective the year around. Although its use is recommended during periods of active growth of plants, spraying of ORANGE during the dry or dormant season will ultimately produce defoliation. With heavy jungle, a less dramatic effect will be achieved in the dry season and a longer period of time will be required for effect.

Section V. CONCEPTS OF EMPLOYMENT

The employment of herbicides for military purposes must be judiciously controlled by the technically qualified and trained Chemical officer. Many unforeseen and undesirable aftereffects may arise unless the user is thoroughly familiar with the type of plant life to be attacked, the best selection of a herbicide to accomplish the task, and the selection of the proper mode of dissemination. Herbicides may be employed as disiccants (BLUE) to dry up foliage, as a growth regulator (ORANGE) to kill the broadleafed vegetation, or as a soil sterilant (HYVAR-X) to prevent the growth of green plants when applied to soil. Since all herbicides are chemical compounds specially blended for specific application, it is necessary for the user to know the kind of vegetation he wishes to attack and which chemical compound does the job most effectively.

Guerrillas rely heavily on the local farmer for their food supply; thus, the food supply of the guerrilla is one of his vulnerable areas for attack. Elimination of his food supply seriously affects the capability of the guerrilla to resist. Aerially delivered herbicides provide an efficient means of destroying crops.

The natural dense vegetation in jungle areas is ideal for the illusive hit, run, and fade-away tactics of the guerrilla. If this dense growth can be defoliated or eliminated, the guerrilla may then be found, pursued by friendly forces and destroyed. His propaganda that the agents used are poisonous has back-fired and the Viet Cong soldier is currently afraid to stay in a sprayed area or eat food affected in any way by the spray materials.

a. Military Use.

Herbicides may be used most effectively to--

(1) Clear the vegetation bordering jungle roads, paths, trails, and waterways, thereby reducing possible sites from which friendly forces may be ambushed.

(2) Destroy guerrilla food supply.

(3) Reveal enemy trails, supply routes or installations in forested areas.

(4) Clear the vegetation from fields of fire, and avenues of approach.

(5) Significantly reduce vegetation growing in minefield and wire barriers.

(6) Clear the vegetation surrounding critical installations, communications complexes, air defense sites, railroad and pipeline rights-of-way, petroleum warehouses, and air fields.

(7) Clear field training firing ranges and mark the boundaries of firing lanes and impact areas.

(8) Clear "kill lanes" which channalize enemy approach and withdrawal during attacks.

(9) Clear large areas of dense vegetation for major construction projects or for health and sanitation reasons. Herbicides may be used to mark areas in jungle terrain through which roads are to be built. Such marking also results in plant drying and eases the

job of clearance. If it is desired to remove the dead tree trunks and branches of defoliated areas, the area after drying may be burned, or the dead matter removed by cutting, bulldozing, or some other physical method.

b. Employment Considerations.

On the basis of their response to herbicides, there seems to be a basic dichotomy in the plant world between broadleaf (bean) and narrow leaf species (grasses, rice, sugar cane). Agent BLUE (the sodium salt of cacodylic acid) has been found to be the most effective agent for the grasses. The 2,4-D and 2,4,5-T combination (ORANGE) has been found to be the most effective on the broad range of species found in a jungle area.

Although BLUE is the agent of choice for rice, ORANGE can also be effective in certain circumstances, but at a much higher dosage rate. ORANGE at very low doses selectively destroys broadleaf weeds in grass or grain fields, but can kill the narrow leaf plants themselves (e.g. rice) at much higher doses.

Although five gallons of ORANGE per acre have never been experimentally employed on rice, it is safe to conclude from the evidence available that this dose would kill a rice crop. Five gallons of ORANGE contains more than 25 pounds of 2,4-D ester plus 25 pounds of 2,4,5-T ester. Experimental evidence dating from 1945 shows that two and one-half pounds per acre of n-butyl ester of 2,4-D in fuel oil reduced rice yields 40%. In another experiment in 1946-47, four pounds per acre of n-butyl ester of 2,4-D and 2,4,5-T n-butyl esters gave, respectively, 29 percent and 48 percent yield reduction. From 1954, there is evidence that five pounds per acre of n-butyl ester gave 34% yield reduction while 2,4,5-T gave 48% reduction. All of the rice in these studies was sprayed during its growing period and the yield reduction was made on the basis of the weight of the harvested grain compared to untreated rice plots. It is reasonable to conclude that 50 pounds of combined 2,4-D and 2,4,5-T contained in five gallons of ORANGE would kill rice plants.

In contrast with ORANGE, BLUE has produced 100% rice yield reduction at 0.5 pounds per acre in an experiment conducted in 1957. In order to provide a margin of safety, a dose of one gallon per acre of BLUE is recommended for use in Vietnam.

A rice field sprayed with five gallons per acre of ORANGE will show effects in about 24-48 hours. The first response will be a darkening, water- or oil-soaked appearance followed in two to three days by a drying and shriveling of the leaves. Leaf color generally changes to light grey or tan.

If a sub-lethal dose is applied to rice, new lateral shoots (tillers) may arise from the plant at ground level and produce grain even though the foliage and aerial portion of the plant may appear to be dead shortly after being sprayed. The yield of grain is delayed and will be less than unsprayed rice.

ORANGE should be applied no later than one month before harvesting; however, if five gallons per acre are to be used because of the severe contact injury which that dose produces, ORANGE can be applied through the flowering stage.

If 1 gallon per acre of BLUE is applied, effects are apparent in a few hours. However, if 0.5 pounds (about 1/6 of a gallon of liquid BLUE) per acre is applied there may be no apparent effect. The plants appear to be healthy and normal except at harvest time, there is little or no yield.

In regard to dosage rate versus kill or defoliation, defoliation does not necessarily become meaningfully accelerated by the use of excessive quantities of ORANGE. Contact injury to the foliage becomes obvious sooner, but leaf drop is not necessarily expedited. It is, therefore, recommended that a separation of dosages, one for killing and one for defoliation, not even be contamplated or used as a concept with ORANGE. The successful use of ORANGE should be thought of in the sole sense of killing vegetation (permanent defoliation). And most important, it does not follow that in the dry season when jungle growth is dormant, doubling to tripling the quantity of spray will overcome the natural dormancy and cause early abscission.

A heavier use rate (increase in gallons) is recommended for defoliation of forest trees than for desiccation of rice even though the trees are broad-leaved and therefore more susceptible to ORANGE than is rice, a narrow-leafed plant. The reason for this is that there is a much greater mass of vegetation in one acre of forest than there is in one acre of rice. One acre of forest may easily contain 300 metric tons of plant material and the leaf surface of this vegetation is the equivalent of many acres. In contrast, the rice plants are only three to four feet all, succulent, rapidly growing and the entire mass may be only 10 to 20 tons per acre. The leaf area also is much smaller when expressed on an acre basis. It takes more chemical to kill the greater mass of vegetation and more liquid to cover the greater number of exposed leaves.

In addition, in jungle areas, some of the spray droplets filtering down through the forest canopy impinge on the bark of the trunk and branches and although ORANGE can be absorbed by leaves, stems and roots, penetration through thick layers of bark is slow and inefficient and much herbicidal effectiveness is lost when droplets impinge on the bark. While basal sprays are sometimes made to the trunk of a tree for vegetation control in the United States, the entire area of the trunk from a height of about three feet to ground level must be saturated with the herbicide to obtain kill using this method.

Another factor involved in plant age. Resistance to herbicides increases with increase in age of the plant material. Also, succulent tissues are much more susceptible than hardened, woody tissues.

c. Factors to be Considered Before use of Herbicides.

Written requests for crop destruction or defoliation missions originate with units in the field. Items to be considered prior to approval of these requests include:

(1) Overlays or annotated photographs depicting the exact area.

(2) Target list.

(a) Description of the area (to include the province or district).

(b) UTM grid coordinates.

(c) Length and width of the target area. This may be expressed in feet, yards, meters, acres, or hectares.

(d) Type of vegetation or crop (to include planting and harvest times for crops).

(e) Recommended method of applying the herbicide.

(3) Psychological warfare considerations, such as leaflet and loudspeaker announcements.

(4) Civil affairs considerations to provide food or money to families whose crops are accidentally damaged by the operation.

(5) Certification release by the local province chief indicating his approval and indorsement for the defoliation operations.

Section VI. SOIL STERILANTS AND DRY HERBICIDES

The use of pelletized, granular, or powdered material as soil sterilants will usually require a relatively large amount of material to be applied on a per acre basis. This is primarily because these dry materials have to be diluted by rainfall and carried into the soil to the root zone. Additionally, commercial products range from perhaps 80 percent to as little as 10 percent active ingredient.

If truly bare ground is a requirement, the expense to obtain this condition will be relatively high. Mud, dust, and erosion conditions may be unforeseen but can easily become major problems after achieving a bare ground result. It is also possible that to maintain a bare ground condition may require a continuing chemical program.

Granular or pelletized herbicides may be of interest for the following reasons:

a. Drift of liquid sprays on desirable vegetation such as crops in friendly areas could be avoided. However, fine dust resulting from handling, shipping and storage may also cause some drift damage.

b. The dissemination of dry materials could be performed by men with no special equipment other than a container from which handfuls of the material could be scattered. Such a situation assumes ground access.

Costs of granular or pelletized material for clearing vegetation are relatively high compared to the use of sprays.

Soil sterilants may be classed as:

(1) Temporary. Soil remains toxic to green plants for not more than four months.

(2) Semi-permanent. Soil remains toxic for at least four months, but not longer than two years.

(3) Permanent. Soil remains toxic longer than two years.

The above groupings are arbitrary and are not iron clad. For instance, manipulating the dosage of a given chemical could cause it to be classed either as temporary or as semi-permanent. The period of effect is also dependent on such factors as the rate of microbial decomposition of the chemical, rate of chemical decomposition, adsorption by various soils, rate of leaching, volatility, etc. Generally, leaching is most rapid in sandy soils. Environmental factors such as temperature and soil moisture which influence microbial activity also influence the rate at which the chemicals may be decomposed by organisms.

Pelletized herbicides will require water after they have been disseminated, so that the active ingredient can be carried in solution into the soil to the root zone. Unless water is to be supplied artificially in areas where these pelletized herbicides are to be disseminated, the use of these herbicides will be restricted to periods when rain occurs frequently.

Most soil sterilants should not be applied closer than 50 to 100 feet from adjacent crops in locations where drainage from treated areas flows onto crop land in a friendly area.

Section VII. DISSEMINATION EQUIPMENT

There are several devices that are available for the dissemination of materials whether as dusts or powders, granules, or pellets, or as liquids.

For disseminating pellets or granular materials, the simplest procedure is for a man to hold a container and broadcast the material by hand as though he were sowing grain. Some obvious limitations are the limited area one man can cover and ground access is required. Larger areas could be covered by one man on the ground using a "Mity Mite" which can spread granules or pellets up to about 50 feet.

There are ground spray units which can be towed or carried and functioned in the bed of a truck. The Buffalo Turbine equipment is an example and the CS model has been used in Vietnam.

If the Buffalo Turbine with a 100-gallon tank is used for ground application of liquid sprays of soil sterilants (e.g. Hyvar-X) containing water-soluble or wettable powders, a 50-mesh screen should be used in the line strainer. The screen size, of course, should be somewhat smaller than nozzle orifices. Minimum spray volumes of 24 to 48 gallons per acre are required for water-soluble powder formulations of Hyvar-X, since a maximum of one and one-half pounds per gallon of 50 percent active powder is soluble.

Several types of sprayers or techniques may be used. These include the use of:

a. A 3-gallon hand-pump sprayer.

b. The M106 riot control agent disperser (Mity Mite).

c. The power driven decontaminating apparatus (PDDA).

d. Commercial orchard sprayers (numerous models are manufactured).

e. Aerial spray tanks mounted on either high-performance aircraft, cargo aircraft, low-performance fixed-wind aircraft, or helicopters.

The capability of the system as regarding type of aircraft, flow rate, particle size, mass median diameter, and resulting swath widths of deposit levels desired will have a bearing on the spray mission. Weather and terrain conditions also have to be recognized. Usually, airspeed and altitude are fixed for a given system and spraying should be limited to appropriate weather conditions, inversion conditions being preferred with winds not exceeding 5 to [illegible] knots. Usually, inversions are encountered for an hour or two after sunrise and again near sunset. Spraying during midday should not ever be considered unless it is a very special situation with sprays to be delivered "on the deck" and even then a major proportion of the spray is likely to be wasted and even worse may cause extensive damage elsewhere where it is not wanted.

It would appear in many, if not most, instances that helicopters could be used for spraying of the installations, mine fields, and wire barriers. [illegible] the power driven decontamination apparatus (M12A1) would be needed to disseminate spray materials. The Army has procured a spray system of 196-gallon capacity, suitable for use in the UH-1,B/D, which requires no aircraft alteration. This system was originally designed for insecticide spraying, but has proved to be well suited for herbicide missions. The system is self contained and requires only being tied down to the cargo shackles in the floor of the aircraft. It can be installed and removed in a matter of minutes so the aircraft need not be "grounded" and used only for spray missions. At altitudes of 25 to perhaps 50 feet, sprays released from helicopters have a degree of aimability, particularly where the spray consists of relatively large droplets. Under appropriate meteorological conditions for spray settling, altitudes of up to 75 feet have been used successfully.

The [illegible] herbicide dispersal apparatus, liquid (FIDAL) concept appears to have a place in supplementing a spray capability in Southeast Asia. [illegible] can be hung on A-1E or A-1H aircraft without modification to the aircraft. The tanks can be filled to about [illegible] to [illegible] gallons each hung on the aircraft giving a total load of about [illegible] to [illegible] gallons. As modified from the original prototypes, Allison [illegible] turbines governed at 4,000 rpm's operate centrifugal pumps to force the liquid to be sprayed through a spray boom. Spray missions would not tie up these aircraft because the tanks could be hung or removed in minutes. Cost of the units is considered modest in comparison to the 1,000-gallon inboard system for the C-123 cargo plane. In an emergency, the tanks could be jettisoned in flight. For further information, Fort Detrick Technical Report 46 and Supplement III to TR 46 are available at the ARPA, R & D Field Unit, at 4A Bach Dang, Saigon. There is also a 1965 report on "Safe Havens" by the Research Analysis Corporation for ARPA prepared for distribution in Mid-December 1965 which contains additional information (RAC-TP-191; Sept 1965). For further information, some additional reports may be of interest:

1. "Vegetational Spray Tests in South Viet Nam and Supplement (U)," U. S. Army Biological Laboratories, Fort Detrick, Maryland, April, 1962, Classified SECRET.

2. "Destruction of Viet Cong Crops, RVN; Attack of Tgt 2-1, 21 and 23 November 1962 (U)," USMAC-V, 17 December 1962. Classified SECRET.

3. USMAC-V, Task Force Saigon Evaluation Team, "Evaluation of Herbicide Operations in RVN, September 1962 - September 1963," 10 October 1963. Classified SECRET.

4. "Defoliation, Crop Destruction, and Riot Control Operations in II Corps Tactical Zone. Republic of Vietnam (U)" September 1965-September 1966. Classified SECRET.

5. "Research and Analysis Study ST 67-003 Evaluation of Herbicide Operations in RVN (U)." Classified CONFIDENTIAL.

6. "Review and Evaluation of ARPA/OSD 'Defoliation' Program in South Vietnam." 1962.

Information is presented regarding ORANGE, PURPLE, PINK, BLUE, WHITE, Bromacil and UROX 22. ORANGE and BLUE (liquid) have been recommended for particular uses. PINK, BLUE (powder) and PURPLE have been phased out of procurement and are mentioned only because some stocks may turn up in out of the way places. WHITE has not been recommended but has been procured for use when ORANGE is not available. Bromacil (HYVAR and UROX 'B') and UROX 22 (granules) are mentioned in the event "soil sterilants" are required.

ORANGE

Physical Properties

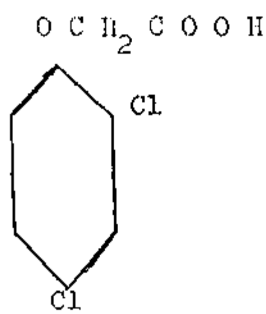
ORANGE is a 50-50 mixture by volume of:

n-butyl 2,4-dichlorophenoxyacetate and

n-butyl 2,4,5-trichlorophenoxyacetate

Commonly the mixture is referred to as a 50-50 mix of the n-butyl esters of 2,4-D (two, four-D) and 2,4,5-T (two, four, five-T).

The active principle is shown as in the acid of 2,4-D:



and the right hand H may be replaced by any number of salts such as sodium, ammonium, potassium, and others or by many other esters such as methyl, ethyl, iso-butyl, propyl, and advertised as a "low-volatile" ester, butoxyethanol ester. The salts named above and the acid are non-volatile and are normally solids while the esters may be liquid depending on the temperature and may have varying degrees of volatility. The n-butyl ester of 2,4,5-T is normally solid below 77° F. but normally liquid above this temperature. However, the n-butyl ester of 2,4-D solidifies about 4[illegible]° F. a much lower temperature. A mixture of the two, as in ORANGE, tends to solidify at about 45° F. but liquifies again as the temperature rises and remains above this level. The esters in ORANGE have a tendency to supercool, that is, remain liquid below the freezing points given above for varying periods of time. As the temperature drops, the viscosity of these materials increases and some determinations for ORANGE are presented below:

Temperature C	Viscosity Centipoise
60	10.0
50	13.2
40	19.3

Temperature C	Viscosity Centipoise
30	34.5
25	45.4
20	62.0
18.1	70.8
13.8	102
5.9	220
1.6	333
-3.9	800
-23.6	25300
-25.5	45200

Obviously, where a centrifugal pump is used in a spray system and spraying is done at two different temperatures, less material will be released at the lower temperature even though the same pump rpm is used. This is why flow meters were recommended for the C-123 systems.

Mixture consistsing of:

Inert ingredients - less than 5%.
50% n-butyl ester of 2,4,5-trichlorophenoxyacetic acid
50% n-butyl ester of 2,4-dichlorophenoxyacetic acid

Freezing Point . . . . 45 F.
Solubility . . . . soluble in ether, diesel fuel oil, acetone, and alcohol.

Formulation

ORANGE is miscible with oils and 95-100% of the mixture is present as active ingredient. It weighs about 10.75 pounds per gallon.

This mixture is noncorrosive to metals, nonexplosive, and fire-resistant, stable in storage and is supplied to the field in unlined, mild steel 55-gallon drums. Rubber hoses used for agent transfer will deteriorate and require replacement. Contaminated aircraft must be washed with soapy water to remove the agent. ORANGE will remove aircraft walkway coatings and aircraft paint. Fabric aileron surfaces deteriorate and will require replacement depending on frequency and length of herbicide exposure.

ORANGE is currently the Standard A formulation supplied to Southeast Asia and is procured by the Air Force.

Drums of ORANGE are shipped to the combat zone in black painted drums with a wide orange painted band around the middle of the drum.

ORANGE may soften the soles of combat boots on repeated or extended exposure and personnel should be careful to minimize spillage and contact with rubber surfaces.

The "pure" liquid esters are soluble in most organic solvents and in brush control work diluting the esters with #2 diesel fuel oil is not uncommon. The salts are used in aqueous solutions. ORANGE, at this writing, is not known to have been diluted for use in RVN. These "volatile" esters have been recommended to aid in canopy penetration in the dense jungles. Their volatility is not anywhere near that of gasoline, ethyl alcohol, acetone, and the like, and in an open dish at room temperature for 5 days less than 0.5% by weight will be lost. However, in a closed room in the seventies the distinctive odor of ORANGE would be apparent if a small vial or a bottle were left open. The vapors of ORANGE are effective on vegetation, but usually only for a relatively limited distance in the open.

The spray of ORANGE is most effective on a given tree or plant if every leaf receives a spray drop. It can be more effective if the same amount of ORANGE could be applied as several drops to each leaf.

After a tree or plant is exposed to a spray of ORANGE, the material is absorbed by the leaves and is moved internally in the plant system to the aerial growing points and to the roots causing the food reserves available for the plant growth to be used up at an accelerated rate and essentially wasted.

Although the addition of surfactants to aqueous solution of 2,4-D and 2,4,5-T does enhance the biological effect of these materials, adding them to the "pure" esters is not necessary. It is possible, though, to add #2 diesel fuel oil to the esters to obtain better coverage, i.e., more drops or droplets per leaf. Sprays of liquid esters are able to penetrate the wax covering of most leaves quite well compared to the use of aqueous sprays and are effected far less by rain occurring 15 minutes to a half hour after spray deposit.

The best time to apply ORANGE is when the vegetation is actively growing. In the U. S. about one month after the new growth has started is considered a good time. In a tropical jungle where most of the tree species may be broadleaved evergreens, the jungle is green the year around, but in certain countries there is a dry season from December through February, and where this condition prevails the most efficient use of the ORANGE spray would be indicated from April to mid November. There are exceptions, of course, from year to year as the weather conditions may vary. Also, there may be undesirable woody vegetation such as mangrove growing in situations where water is plentiful the year around and under these conditions ORANGE can be used the year around to kill the mangrove and other associated species, such as nipa palm and water coconut.

There does exist variation of sensitivity among species of plants, thus, with a given application rate it is quite possible to kill a relatively sensitive species in one week or less while a more resistant species may not succumb until the passage of a couple of months. Too, there are species which may be unresponsive. Expressed another way, because variation does exist among species in their response to ORANGE it is not practical to adjust the dose for each species, but to try to obtain a practical use rate of ORANGE where by a high percentage of the species (and the individuals of a given species in different stages of growth) will be responsive. Also, when the effect of the spray is developing it will appear to be developing most uniformly in a jungle or forest stand composed of very few different sensitive species and will appear to be quite ragged in developing in a stand consisting of many different species. There have been instances where as many as 2 to 3 hundred different species may be found per acre. In such an instance the effect of the spray can easily be pre-judged before the maximum effect has been achieved. One to 2 months may be required for the maximum effect to develop in a mixed stand. It is entirely possible there have been instances where additional sprays may have been applied in as few as 4 to 7 days after the initial spray where the effect of the initial spray was judged prematurely and foliage that was apparently unaffected was in fact either not sprayed or was sprayed and needed more time to respond.

Use rates of 1 to 1½ gallons of ORANGE per acre have been found to be adequate in mangrove areas throughout the year. In upland situations, 1 to 3 gallons of ORANGE per acre can do the job. It is also possible to provide better coverage with 1 to 1½ gallons of ORANGE if it is diluted with #2 diesel fuel oil at either 1:1 or even at one part ORANGE to two parts fuel oil. It is of interest that in commercial use 1 to 4 pounds of 2,4,5-T per acre are useful in controlling hardwood scrub growth in growing pines for the pulp and paper industry in Louisiana. When this rate is compared with gallon quantities of ORANGE where 1 gallon contains almost 5½ pounds of 2,4-D and 5½ pounds of 2,4,5-T, one can appreciate that a use rate of 1 or more gallons of ORANGE per acre is an appreciable quantity of material. Of course, where the vegetation density is high, the number of species present is high and the jungle canopy may vary in height up to 125 feet, it becomes apparent that more material may be required. There is a point somewhere where boosting rates of application becomes wasteful and it is suggested tha exceeding 3 gallons of ORANGE per acre is becoming wasteful. Doubtless, it is possible up to a point to accelerate obvious effect by increasing the dose, but this does not necessarily imply that the ultimate effect will be correspondingly greater nor does applying excessive amounts during the dry season necessarily overcome the physiological dormancy and ordinary inability of the species to respond that is associated with this dormant condition. Also, there is a tendency to judge the effect by the rapidity with which the foliage turns brown. Normally, a relatively rapid change to brown (say 2 to 4 days) is indicative of contact injury and is not necessarily conducive to the most efficient killing of the vegetation where ORANGE is used.

Where new or different herbicides are mentioned by various sources, it is well to bear in mind the following criteria, which have been applied to PURPLE, ORANGE, and BLUE:

1. Rapid action.
2. Low cost.
3. Lox toxicity for man.
4. Effective at low dosages.
5. Effective at low volumes of delivery
6. Available in large quantities.
7. Relatively non-corrosive.
8. Effective on a broad range of plant species.
9. Low residual soil activity.
10. Relatively high concentrate.

Toxicity

1. A single oral dose in excess of 40 gm is required to produce the LD_{50} in a 180-pound man.

2. Small doses of one gram taken daily have little or no effect on man or animals taken over a one week period.

3. Low dose injuries may consist of eye and skin irritation in sensitive individuals.

4. At usual plant-control doses, ORANGE does not reduce the number of soil micro-organisms significantly.

5. LD_{50} ranges from 300-1000 mg/km of body weight for various animals.

6. Further information is provided in the section on Decontamination.

Information contained in the following reports may be of interest to you:

1. Research Analysis Corporation Technical Paper, RAC-TP-191. September 1965. Neutralization of Viet Cong Safe Havens: A Preliminary Study (U). SECRET (65-FDS-2916)

2. Boyer, L. W. and J. W. Brown. June 1964. Calibration of Spray Systems C-123/MC-1; H-34/HIDAL; A-1H/FIDAL. (Technical Report 46). Director of Biological Research, Crops Division, U. S. Army Biological Laboratories, Fort Detrick, Frederick, Maryland

3. Boyer, L. W. and J. W. Brown. June 1964. The A-1H/FIDAL Concept. (Supplement III to Technical Report 46). Director of Biological Research, Crops Division, U. S. Army Biological Laboratories, Fort Detrick, Frederick, Maryland.

4. Vegetational Spray Tests in South Vietnam and Supplement (U) U. S. Army Biological Laboratories, Fort Detrick, Maryland, April, 1962. SECRET

5. Destruction of Viet Cong Crops, RVN; Attack of Tgt 2-1, 21 and 23 November 1962 (U) USMAC-V, 17 December 1962. SECRET

6. USMAC-V, Task Force Saigon Evaluation Team, Evaluation of Herbicide Operations in RVN, September 1962 - September 1963, 10 October 1963. SECRET

NOTES AND OBSERVATIONS

1. "Although the vapors of ORANGE are capable of causing injury to sensitive broadleaf plants, much unwanted damage in Vietnam may be caused by faulty application procedures. Enclosed is a photo showing four C-123's spraying directly over a rubber plantation. How often is this done with the Air Force crews claiming that 'we weren't within 5-8 kilometers of the plantation'? We have also seen TV film clips showing the planes continuing to spray as they climb and bank at the end of what should have been their spray run. Release of spray material during such a maneuver is bound to cause the agent to drift outside the designated target area."

(R & D director.)

2. "Amine formulations are less active biologically than esters because of the slower rate of penetration into the plant through the waxy leaf cuticle. The butyl esters being employed now as ORANGE are the most active forms of the herbicides. They penetrate the waxy cuticle quite readily and entry into the leaves begins in a matter of seconds. Moreover, rains occurring within a half-hour after spraying with ORANGE are not likely to reduce materially the severity of the plant responses. Aqueous spray drops, however, can be washed off leaves by heavy rains that occur during the monsoon season; thus, reducing the effectiveness of the aqueous sprays. WHITE (Tordon 101) is an aqueous formulation of amine salts and the characteristics of aqueous sprays mentioned above apply to it."

(R & D director.)

3. "Some targets of dense jungle growth have required two applications of ORANGE (at the rate of 3 gal/acre) to provide complete defoliation of the upper and lower layers of vegetation to ground level. Defoliation is an effective means of exposing trails, roads, fortifications, etc., to aerial observation. Defoliation of dense jungle growth along the Saigon waterways, perimeter of Special Forces camps and roads, had provided improved visibility and elimination of ambush cover."

(Statement of representative of 7th Air Force, Saigon.)

NOTE: Exacting determination of weight loss of ORANGE by two separate laboratories showed that less that 5% of the weight of material exposed to air at room temperatures was lost in a ten-day to two-week period of time. The major point therefore to emphasize is not the degree of volatility which, contrary to the thoughts of many is rather low, but the activity of the what material does vaporize. Of course, as temperatures are increased vaporization increases as well.

PURPLE

Chemical Composition

50% n-butyl ester of 2,4-dichlorophenoxyacetic acid
30% n-butyl ester of 2,4,5-trichlorophenoxyacetic acid
20% iso-butyl ester of 2,4,5-trichlorophenoxyacetic acid
Inert ingredients - less than 5%

Type of Chemical

General herbicide used for control of broadleaf crops, jungle, and a wide variety of tropical and temperature climate vegetation.

Physical and Chemical Properties

2,4-D:

Melting point	280-284° F. (138-140°C.)
Appearance	in the laboratory, white to yellow crystalline powder
Solubility @ 22°C.	605 ppm in water soluble in acetone, ether, alcohol
Solubility @ 50°C.	1,490 ppm in water, soluble in acetone, ether, and alcohol
Stability	very stable, noncorrosive, nonflammable, and non-explosive

2,4,5-T

Melting point	304-307°F. (151-153°C.)
Appearance	light tan solid in the laboratory
Solubility @ 22°C.	soluble in alcohol, insoluble in water

Formulation

PURPLE is a mixture of 2,4-D and 2,4,5-T and can be used either straight or diluted with Diesel oil.

Toxicity

2,4-D and 2,4,5-T are considered nontoxic to human beings and animals. They do not significantly reduce total number of soil micro-organisms when applied at recommended rates because of the very rapid detoxification of the chemicals in the soil at military use rates.

2,4,5-T may be slightly irritating to the nose, throat, and eyes. The first report of fish kill from the use of phenoxy herbicides (PURPLE) in Vietnam was received in September, 1962. Fingerlings in shallow water were reported to have died.

Fort Detrick was involved in the first research on these compounds in 1946 and 1947 to control aquatic vegetation, and herbicide tolerances of fish were also conducted at the same time. Fish are able to tolerate the quantities of PURPLE herbicide needed to kill aquatic vegetation. However, if the minimal effective dose is drastically exceeded then fish kill will occur. Tributyl phosphate in early 2,4-D:2,4,5-T formulations in the 1940's was used as a solvent and was found to be considerably more toxic in killing fish then were the herbicides themselves.

Use

PURPLE was the first agent present in the field in Asia in significant quantities. It was to be used on the wide variety of resistant tropical species found in Asia and as a first generation agent was proven to be effective. It is no longer procured, but some quantities may still be found in warehouses and remote locations in Vietnam.

PINK

Physical Properties

Mixture consisting of

60% n-butyl ester of 2,4,5-trichlorophenoxyacetic acid
40% iso-butyl ester of 2,4,5-trichlorophenoxyacetic adid

Appearance .... light tan solid in the laboratory.
Melting point .... 304 to 307 F. (151 to 153 C.)
Solubility .... soluble in alcohol, but insoluble in water.

Formulation

PINK is delivered to the field as a liquid which is soluble in Diesel fuel.* 98-100% of the mixture is present as active ingredient which gives about eleven pounds of active ingredient per gallon.

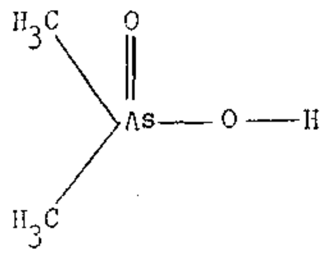
This herbicide is noncorrosive to metals and essentially non-toxic to man and animals.

PINK will remove paint and enamel from aircraft surfaces and will soften rubber products, delivery hoses, and the soles of combat boots. Fabric aileron surfaces will deteriorate and will require replacement once or twice per year, depending upon frequency and length of exposure.

The PINK herbicide mixture was an early formulation supplied to the field for a specific requirement which no longer exists and it is no longer procured by either the Army or the Air Force. Quantities of PINK, however, may still exist at remote locations in the field in Viet Nam and in various warehouses. It is for this reason that this herbicidal mixture is considered in this handbook. PINK is effective on woody and otherwise hard-to-kill species and all available quantities in the field should be used at the earliest possible opportunity. It may be with ORANGE in the ratio of 1:1 or 1:2 to make a "homemade" mixture that will be very effective.

PINK is found in the field in unlined mild steel 55-gallon drums painted black with a broad pink band around the middle of the drum. Many of the pink bands may have faded to white.

BLUE



Dimethylarsenic Acid

Physical properties (pure material):

Molecular weight 137.99
Melting point .... 392° F. (200° C.)
Arsenic content 54.3%
Appearance .... Colorless, crystalline
Solubility @ 20 C. .... 200 g/100 g. H_2O
36 g/100 g alcohol
insoluble in ethyl ether

Specifications

Typical analysis:
Cacodylic acid (anyhdrous) 65%
Trivalent arsenic (as arsenic) .... 0.1% maximum

Inert ingredients:
Sodium chloride 15%
Sulfate (as Na_2SO_4) 19%
H_2O 1%

Price schedule:

1-lb. glass containers .... $4.00/lb.
15 pound net-3lb. tar fiber drums - 11½" x 15".......... $2.00/lb.
100 pound net-7 lb. tar fiber drum - 16" x 26 3/4" ..... $1.75/lb.
Truckload or carload shipments in 100-lb. net drums .... $1.22/lb.

Shipping and handling:

Shipments of fiber drums with polyethylene liners will be made by best routing motor truck or railway freight unless otherwise requested. Six-ounce samples and glass containers will be shipped via parcel post.

Shipping and handling (Continued):

Since cacodylic acid (BLUE) in its spray dried form is hygroscopic, the material should be stored in a dry place and container kept tightly closed when not in use. Contact with the skin, eyes, or clothing and prolonged breathing of dust or spray should be avoided. Acute oral LD for the commercial material is about 1,350 mgs/kg of body weight. Toxicological data follows.

Suggested uses and rates of application:

BLUE is being evaluated for the following potential uses:

1. Forest renovation (to remove certain broadleaf plants)
2. Grass land renovation
3. Defoliant
4. Desiccant
5. Seed fungicide
6. Aquatic weed control

Rates of application are not accurately known because of the variety of uses for this chemical. On a 100 percent active ingredient basis, suggested application rates of $\frac{1}{2}$ to 4 pounds per acre are recommended. For complete eradication of plants, rates of as much as 10 to 15 pounds/acre may be needed.

Technical Aspects

Introduction

There are two forms of BLUE that will be discussed, namely, a dry form and a liquid form. The dry form is mentioned here only for information should some of it still be available somewhere in RVN. It is no longer procured as the dry form, cacodylic acid. The liquid is neutralized to a pH of 6.8 to 7.2 to reduce corrosive properties and has a surfactant added. It is basically the sodium salt of cacodylic acid in an aqueous solution. It is identical with material called PHYTAR 560G. It, like cacodylic (or dimethyl arsenic) acid, contains arsenic characterized by 5 bonds or valences. The arsenic in rat poison has 3 bonds and is quite a different substance from the standpoint of toxicity. Suffice it to say that BLUE, PHYTAR 560G (and cacodylic acid) is less toxic to humans than aspirin.

It is classified as a nonselective desiccant and is effective in drying and shriveling leaves of both broad-leaved and grassy plants. BLUE can produce a relatively rapid defoliation generally without regard to species. Regrowth may occur again in about 30 days. Repeated spraying as necessary ultimately will provide a high degree of plant kill whether the vegetation is woody, grasses, or both.

The ability of BLUE to prevent grain formation in rice without any external effects being apparent is not generally known. However, at the higher dosage rates, BLUE will cause rice plants to shrivel and die in about 48 hours after being sprayed. If sprayed after grain has already been formed, the fields should be burned if the weather permits.

Since BLUE works through foliar absorption only, the foliage must be thoroughly covered with the spray material. The sprayed plants will die in 2 to 4 days or less and can be burned if permitted to dry out thoroughly.

Cacodylic acid is a pentavalent organic arsenical. Compounds of arsenic, such as cacodylic acid, can be separated into three groups according to valence. The groups are plus or minus 3 and plus 5. The pentavalent arsenicals are less toxic to man and animals than are the trivalent.

In 1966, a preliminary study was made on the effects of cacodylic acid on the flora and fauna of specific ecotones. The ecotones studied were sandhills, hammock, grasslands, ponds, and streams. In each ecotone, the direct and indirect effects were studied.

The flora and fauna of any region are closely related to the nonliving environment. Each environment has specific types of flora and fauna which form plant/animal communities. In each community, green plants, as converters of solar energy to food, provide the foundation for all other forms of life. Any consideration of the effects of an herbicide on local flora and fauna must encompass not only direct effects to living organisms but also indirect effects resulting from the destruction or modification of the plant life.

Cacodylic acid can be expected to produce minor modifications in local plant and animal communities when sprayed at concentrations exceeding 2 pounds/acre. The high solubility of this chemical, plus its quick detoxification in the soil, allows recovery of the plant life not actually killed.

The study discussed here found only transitory effects on the organic community and a quick recovery of the local ecotone can be expected in tropic regions. The main effect of cacodylic acid on aquatic fauna is indirect through the removal of the primary oxygen producers such as algae, and there is a direct effect only when the water concentrations exceed 1,000 ppm (30 pounds/acre).

Formulation

Cacodylic acid is available in the field as a white powder having a typical anaylsis as follows:

Cacodylic acid	65%
Trivalent arsenic (as arsenic)	0.1%
Inerts	
Sodium chloride	15%
Sulfates	
Na_2SO_4	15%
$CaSO_4$	4%
Moisture	1.0%

BLUE is packed in 100-pound net weight polyethylene lined tar fiber drums. One-pound bottles and six-ounce sample bottles are also available for experimental purposes.

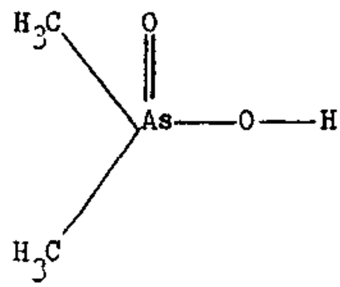
The white powder has a particle size in the 20 to 50 micron range. It tends to bulk pack somewhat, and some small lumps may develop during periods of extended storage. Its bulk density is about 43 pounds per cubic foot. Cacodylic acid is hygroscopic and, therefore, should never be left exposed to the atmosphere in tropic locations with high humidity. It should be stored in a dry place and the container kept tightly closed when not in use.

The activity of the solution can be enhanced almost 200 percent by the use of a surfactant (surface active agent or surface tension depressant). Emulphor EL-620 was the commercial surfactant used in the Vietnam 1962 crop spray missions, * but any detergent or soap will accomplish the same effect. When a surfactant is used, it should be present in about 2.0 percent of the solution, or soap or detergent can be added until the solution begins to form a small amount of suds when the solution is strongly agitated.

* "Destruction of Viet Cong Crops, Republic of Viet Nam, Attack of Target 2-1, 21 and 23 November 1962. (U)" Classified SECRET.

Chemical and Physical Properties

BLUE (cacodylic acid) is a pentavalent organic arsenic compound having the following structural formula:



The molecular weight is 137.99. The pure material has an arsenic content of 54.3%, and has a solubility of 200 grams in 100 grams of water. The technical grade has a solubility of about 80 grams in 100 grams of water. Solubility studies at Fort Detrick indicated that all of the cacodylic acid and salts go into solution at the rate of seven and one-half pounds per gallon of water, leaving only a small quantity of fine sediment. In order to obviate precipitation of either salts or cacodylic acid, it is recommended that you use a solution containing no more than five pounds per gallon.

BLUE is a very stable chemical, and is generally unaffected by either oxidizing or reducing agents. It is also relatively inert in the body, and is excreted in the urine, largely in an unchanged form.

Mixing and Decontamination

Although BLUE is relatively nontoxic, it should not be taken internally. Any of the material that may get on the hands, face or any other part of the body should be washed off at the first opportunity. If clothes become wet with the solution, they should be changed. These are normal sanitary precautions - the material is less toxic than ordinary aspirin.

BLUE is very soluble in water and goes into solution readily. A water solution of BLUE is a very weak acid, and, therefore, spraying equipment should be rinsed with water thoroughly after use.

The liquid form of BLUE (Phytar 560G) which is in use by the Air Force contains about 3 pounds of the sodium salt of cacodylic acid per gallon as compared to the solution made up with the dry powder. It also contains the proper amount of surfactant. Using liquid BLUE eliminates the corrosion problems found in solutions made from the dry powder form of BLUE.

If the dry form of BLUE is applied as a spray of one gallon per acre where no more than five pounds of BLUE material is contained in a gallon, corrosion problems for both the pierced steel planking covering a runway and the aircraft using the runway should not be serious. The first rain of any consequence following the application should wash the material off the planking. In fact, after a week or so, the material in the soil would probably be inactive as far as the vegetation is concerned. If the material is used during the dry season, it might tend to remain as a liquid on the planking because of its hygroscopicity; however, the degree of corrosion obtained with the above use rates would be expected to be relatively harmless. If the dry material is applied unevenly over the planking area, corrosion could be quite noticeable on the planking and conceivably an aircraft running through this powder (or sludge) could throw it up into the wheel wells or other parts of the aircraft. If this is noticed, it could and should be washed off with plain water.

Very "murky" suspensions have on many occasions been sprayed from the HIDAL systems without plugging the pumping system. There is no recycling or recirculating of the spray material with that system and it has sprayed a sludge of 10 pounds of BLUE material per gallon of water, which is twice the concentration currently recommended. The spraying capability of the systems in the C-123 aircraft exceeds that of the HIDAL and has as good a capability for recirculating the spray material. It is not likely that the C-123 system would become plugged. The solution of BLUE can be prepared in drums and allowed to settle, and the supernatant liquid pumped into the C-123 tank.

The amount of dry BLUE material on hand in January, 1966 (about 100, 000 pounds) in Vietnam would suffice for about 20 C-123 sorties. One C-123 sortie could cover about 960 acres of rice using five pounds of BLUE in one gallon of water per acre. It is not conceivable that 20 sorties within one month for one C-123 system would cause any appreciable corrosion to that system, particularly if it is adequately flushed with water after each sortie. Of course, particular care should be taken on filling the system to avoid any overflow or otherwise allowing the material to splash the inside or outside of the aircraft. Once it is allowed to get under the floorboards, it may be difficult to wash away. The flushing should be complete, that is, all contaminated surfaces should be flushed with plain water, the system should be filled with water, functioned, and the flushings discarded. It is recommended that no more than five pounds of the BLUE powder currently on hand be used per gallon of water. This mixture may yield some sediment on standing. However, it is not a hard sediment; it is more like a slimy white mud, and plugging the pump system is not likely as a result of the material standing overnight. However, there is no harm in decanting the clear supernatant and using it.

The form of BLUE recommended for re-supply in mid-1966 is an aqueous liquid formulated at about pH 7.0 and contains 5.0% surfactant. The military specifications for liquid BLUE were written as an answer to the problem of corrosiveness and to provide a form of BLUE that could be used in the field without additional mixing. Any vapors resulting from the liquid are quite harmless.

As it is easier to apply small volumes to large areas by aircraft than by hand sprays, the solutions recommended for use in hand sprayers will be much more dilute than those recommended for aerial sprays.

Because the UC-123B aircraft and the CH-34 helicopter spray systems are capable of applying one gallon or more per acre without major modification, the five pounds of BLUE recommended for rice destruction can be dissolved in one gallon of water and sprayed at the rate of one gallon per acre. The solution can be prepared by adding 250 pounds (two and one-half fiberpak cartons) of BLUE powder to water in a 50-gallon drum, stirring until dissolved and adding water to bring the volume up to 50 gallons. One quart of Emulphor EL-620 or any equivalent detergent or soap surfactant should be added to the solution. The solution can be permitted to stand for a few minutes to allow impurities to settle and the supernatant can be pumped into the spray tank using a filter over the end of the transfer hose inlet.

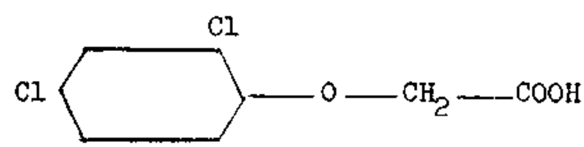
For hand spray operations, it is impossible to spray a volume of one gallon per acre. However, this volume could be applied uniformly to about 1,000 square feet (40 feet by 25 feet), giving a volume of about 40 gallons per acre. In order to prepare solutions for hand spraying, five pounds of BLUE powder should be dissolved in 40 gallons of total solution. One quart of surfactant should also be added to this total volume.

These sprays will be more effective the larger the volume of liquid used, within limits, since more thorough coverage of the plants can be achieved with the larger volumes. Spray volumes up to 100 gallons per acre are frequently used commercially if the grass is dense and tall. When spraying tall grasses such as elephant grass and sugar cane, it is advisable to use large volumes (100 gallons per acre) in order to adequately cover the large amount of vegetation present. This large gallonage per acre is feasible with helicopter mounted systems.

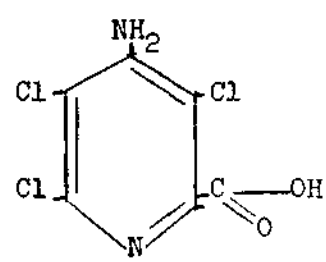
The cost of liquid BLUE (Phytar 560G) is about the same as BLUE powder now on hand in Vietnam, that is, one gallon of Phytar 560G at $5.40 per pound would be somewhat cheaper than one gallon of water containing five pounds of BLUE powder at $1.22 per pound. BLUE as the dry powder is not now in procurement. The switchover from BLUE (cacodylic acid as the dry powder) to Phytar 560G (sodium cacodylic acid in aqueous solution at pH 7.0 plus 5% surfactant) was made to overcome corrosiveness and to provide a material that can be sprayed directly in the field without mixing.

WHITE (Tordon 101 Mixture)

WHITE has been procured for use only where supplies of ORANGE are not available. Note that 80% of its active ingredients are a form of 2,4-D - a basic ingredient of ORANGE and the the commercial name, TORDON, reflects only the picloram portion or 20% of the active ingredient. In addition, the total of the active ingredients reflect only somewhat less than 25% of the solution. In contrast, ORANGE contains 95% or more active ingredient.



4-amino-3,5,6-trichloropicolinic acid (picloram)



2,4-dichlorophenoxyacetic acid

Physical properties (pure material) picloram

Molecular weight 241.5
Melting point .... 209.5 - 210 C.
Appearance .... White powder with a chlorine odor
Solubility @ 25 C. .... 430 ppm in water
Insoluble in oils

Specifications

Active Ingredient:
2,4,-D (tri-isopropanolamine salt) 80.0%
4-amino-3,5,6-trichloropicolinic acid 20.0%
(tri-isopropanolamine salt)

Inert ingredients .... less than 1.0%

Approximately 2.0 lb. of 2,4-D and 0.54 lb. of picloram is contained in each gallon of the herbicide.

Price schedule:

55 gallon drums.................................... Approx. $20.00/lb.
$7.58/gallon

Suggested uses and rates of application:

WHITE is being examined as a general purpose herbicide and is undergoing limited field tests to compare it with ORANGE. It is effective on many plant species, though considerably more expensive, slower in action, and requires higher quantities to equal the effect of ORANGE. At least 5 gallons/acre are required on jungle vegetation.

WHITE is noncorrosive, nonvolatile, nonflammable and low in toxicity. The LD_{50} is 8,200 mg/kg of body weight.

Technical Aspects

A herbicide, known chemically as 4-amino-3,5,6-trichloropicolinic acid, was introduced by the Dow Chemical Company in 1963 under the trademark Tordon and the common name, PICLORAM. This herbicide is rapidly absorbed by both leaves and roots and is readily translocated in plants.

Laboratory studies have shown that the degradation of picolinic acid in soil occurs slowly while leaching occurs rapidly in most soils. A related chemical, 4-amino, 3,5,6-trichloro-2- (trichloromethyl) pyridine, is only slightly soluble in water and leaches slowly. This compound hydrolyzes to picolinic acid in the soil and tests in combination with WHITE and other herbicides have been conducted to determine its utility where various leaching rates are required.

In general, WHITE has showed a selective and delayed herbicidal action on woody vegetation. It is not effective in controlling ash and some species of oak in the United States that respond readily to ORANGE and PURPLE. It also failed to affect some conifers such as red cedar. When compared on a pound per acre basis, WHITE appeared to be equal to or more effective on more woody species than ORANGE or PURPLE. Application of WHITE alone at a rate of 2.8 pounds per acre during the later part of the dry season in Thailand yielded only marginal results. Rainy season applications of WHITE were made only in mixtures with other herbicides and are therefore not strictly comparable.

In studies conducted by Fort Detrick, excellent results were obtained, but fairly high application rates of WHITE were used. These high rates, 5 gallons per acre and more, exceed the capacity of spray equipment now in Vietnam without making repeated spray passes.

Based on the responses of scrub vegetation found under power lines which is generally only 10-20 feet tall and which requires a minimum of 1.5 pounds of picolinic acid plus 6 pounds of 2,4-D per acre, the requirement for the type of vegetation found in Vietnam would most certainly exceed 2.0 lb picolinic acid and 8 lbs of 2,4-D per acre as a minimum. On a cost basis this would be approximately $40.00 per acre as compared with approximately $18 to $21 per acre for 3 gallons per acre of ORANGE which has been providing effective results in the Republic of Vietnam.

One gallon of WHITE contains 0.54 pounds of picolinic acid and 2.0 pounds of 2,4-D amine; therefore, a minimum of 4 gallons of WHITE per acre would be required.

The criteria used for selecting herbicides for use in Southeast Asia are:

1. Rapidity of action
2. Low cost
3. Low toxicity for man
4. Effective at low dosage
5. Effective at low volumes
6. Available in large quantities
7. Noncorrosive
8. Effective on a broad range of woody species

WHITE fails to surpass ORANGE in the following respects:

1. Rapidity of action--it is considerably slower than ORANGE.
2. Cost per pound--approximately $20 compared to approximately $0.75.
3. Cost per acre treated--approximately $40 compared to approximately $21.
4. Vixcosity @ 75 F.--246 to 329 centipoises for WHITE compared to 43 centipoises at the same temperature for ORANGE.

WHITE surpasses ORANGE on a pound per acre basis.

WHITE is a proprietary material and single source procurement is required.

WHITE is being used in lieu of ORANGE where the latter is not available.

Formulation

Picloram is white powder with a chlorine odor. It is usually formulated as the tri-isopropanolamine salt and is available commercially as Tordon 101 mixture (agent WHITE) and Tordon 10K pellets. The pellets contain 11.6 percent of the potassium salt of 4-amino-3,5,6-trichloropicolinic acid. The pellets are extruded and 5/32 inch in diameter.

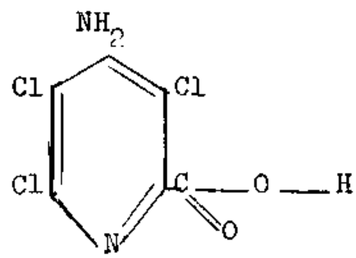
One of the two principle active ingredients in Tordon 101 Mixture (WHITE) is 2,4-D (80%) which is present as the tri-isopropanolamine salt. The other active ingredient is picolinic acid (20%) referred to by the Dow Chemical Company as Tordon, also present as the tri-isopropanolamine salt. This formulation contains approximately 2 pounds of 2,4-D and 0.5 pound of picloram per gallon of aqueous solution.

Aqueous formulations are not recommended for use in Vietnam because of the ease with which they can be washed off leaves during the frequent periods of heavy rain that occur during the growing season. Moreover, oily materials such as the butyl esters of 2,4-D and 2,4,5-T penetrate the waxy cuticle of the leaves much more rapidly than do the water soluble amine salts.

An important factor associated with the use of WHITE (Tordon 101 Mixture) is the large volume of spray solution normally used. The manufacturer has recommended diluting one gallon of WHITE in 10 gallons of water for aerial application per acre to vegetation that is 6 to 8 feet tall. This high volume is completely unfeasible in most large-scale military applications. No information is currently available to Fort Detrick on the effectiveness of low volumes of WHITE. From the logistics and operational viewpoints, it would be desirable to spray the material undiluted; however, data are lacking on the efficacy of such treatments with WHITE.

Chemical and Physical Properties

Picloram when combined with 2,4-D is a very active herbicide (agent WHITE) have some use as a substitute for ORANGE. The structural formula for picloram is:



4-amino-3,5,6-trichloropicolinic acid

The acid has a molecular weight of 241.5 and is a white powder when technically pure. It has the slight odor of chlorine. At 25 C. the technical grade has a solubility of 430 ppm in water; 5,500 ppm in isopropyl alcohol; 20,000 ppm in acetone; 160 ppm in xylene; 10 ppm in kerosene, and is completely insoluble in oils.

WHITE is manufactured as the tri-isopropanolamine salt and is extremely soluble in water.

The viscosity of WHITE is more than 8 times higher than that of ORANGE at the same temperature, and this extremely high viscosity has resulted in overtaxing the loading and discharge pumps on the spray systems present in Vietnam.

WHITE	Centipoises
75 F.	246 to 329 range
90 F.	127 to 171 range
100 F.	89 to 108 range
130 F.	40

TOXICOLOGICAL INFORMATION

Acute and subacute toxicity studies have been conducted with Tordon (picloram) herbicide. Two-year dietary feeding studies are now in progress with both rats and dogs. The following information has been obtained from experiments already completed.

Acute Oral Toxicity Studies

Tordon has a low acute oral toxicity. The LD values for rabbits, mice, guinea pigs, chicks and rats range from approximately 2 (for rabbits) to 8.2 grams per kilogram of body weight (for rats). These data indicate that Tordon herbicide presents a low degree of hazard from accidental ingestion (roughly, the same degree of hazard as common table salt), hence it should not pose a health problem by this route when used according to accepted methods of handling agricultural chemicals.

Subacute Toxicity Studies

Ninety-day dietary feeding tests conducted on rats indicate that Tordon is low in chronic toxicity. A level of 1,000 ppm of Tordon (0.1%) in the diet caused no observable adverse effects as judged by the usual chemical and pathological tests. Levels of 3,000 ppm (0.3%), and higher in the diet, resulted in modest effects on the liver.

Tordon was administered by gelatin capsules orally to sheep at 100, 200, 400 and 600 mg/kg of body weight, using one animal at each level. Four yearling sheep were given 25 mg/kg of body weight each day for 33 days. Short yearlings calves were given 200 and 300 mg/kg of body weight with one animal per dosage level. None of the animals showed any evidence of ill effects.

Tordon was included in the rations of swine and chickens that were self-fed. Duplicate lots of 10 pigs each were fed for 6 weeks a growing fattening ration which contained Tordon at 45 ppm. Duplicate pens of 150-day old chicks were fed a diet containing 45 ppm of Tordon for 8 weeks. There was no decrease in weight gains or feed conversion in these tests.

Eye Contact Studies

Tests conducted on rabbits suggest that undilute Tordon may be capable of causing moderate transient eye irritation, but it should cause no significant corneal injury. Hence, it may be considered to present but slight hazard from eye contact.

Skin Contact Studies

Skin tests, using rabbits as the test animals, indicated that Tordon may cause only very mild irritation of the skin, should exposure be prolonged and excessive. An occasional contact should cause no significant skin effects. Quantitative data on rabbits show that Tordon presents no significant hazard from absorption through the skin. The LD_{50} value for rabbits by this route was found to be greater than 4 g/kg of body weight, the highest dose tested. Thus, Tordon may be considered to present a low degree of hazard from skin contact.

Fish and Other Aquatic Organisms Toxicity Studies

Exploratory tests were conducted to determine the toxicity of Tordon to fish. Untreated Lake Huron water at 50 F was used in the test which was run for 96 hours. The maximum concentration causing no apparent ill effects for the pugnose minnow (Opsopoeodus emiliae, Hay) and green sunfish (Lepomis cyanellus, Rafinesque) was in the range of 10 to 25 ppm. Additional tests are being conducted to further determine the maximum concentration causing no apparent ill effects and TLm's for several species of fish. Ramshorn snails (Planorbis sp.) and daphnia (Daphnia sp.) were maintained in tap water containing various concentrations of Tordon for 72 hours ar 70 F. Test organisms were not affected at concentrations of 30 ppm, but injury did occur at 40 ppm.

Suggested Handling Precautions

Tordon presents no unusual health problems for handling. However, it would be prudent, as with all chemicals, to practice reasonable care and personal cleanliness to avoid skin and eye contact.

Suggested First Aid Measures

Should eye contact occur, flush with plenty of water and get medical attention should any irritation develop.

As a matter of good practice, excessively contaminated skin should be flushed with plenty of water. Clothing that is noticeably contaminated should be removed and cleaned before re-use. If any skin irritation develops, medical attention should be obtained.

Mixing and Decontamination

The quantity of WHITE (Tordon 101 Mixture) required to effectively control tropical forest trees, some of which may be over 100 feet tall, based on the manufacturer's recommendation for the control of vegetation 6 to 8 feet tall cannot be accurately determined.

The usual dosage of the 2,4-D and 2,4,5-T brush killers used along power lines in the United States is about 2 to 5 pounds of acid equivalent per acre. The dosage of ORANGE being used now in Vietnam is approximately 3 gallons per acre, or roughly 24 pounds per acre of acid equivalent. This is a 5- to 12-fold increase to take care of the larger size and greater density of vegetation. If one applies the same factor to WHITE, the quantities that would be required to control Vietnamese jungle vegetation would be 5 to 12 gallons per acre. Even the lower figure of 5 gallons per acre exceeds the spray capability of the C-123 aircraft for a single pass. If 12 gallons per acre were required, then four passes would have to be made over each target in hostile territory. Obviously, these gallonages are unacceptable.

To use WHITE at $7.58 per gallon the cost would be between $39.90 and $90.96 per acre, a considerable increase over the cost of the materials presently being used, with no assurance at this time that these low volumes of WHITE would be as effective as ORANGE at $18.00 per acre.

WHITE is readily soluble in water and is noncorrosive, nonflammable, and nonvolatile. Equipment used to spray WHITE is not readily decontaminated. Warm, soapy water or water containing household ammonia (1 gallon per 100 gallons) and soaking 18 to 24 hours have been suggested to get rid of residues of picloram if the equipment is to be used for another spray purpose, such as spraying insecticides.

When agent BLUE is used in the same equipment as WHITE, caution should be exercised to insure that all of the WHITE is removed before adding the BLUE. When WHITE is added to a solution of BLUE, a precipitate of sodium 2,4-D is formed that will clog the spray system. In the C-123 spray system, the tanks cannot be completely emptied, and about 50 gallons of the spray material remains in the tank. To avoid mixing this residue with the agent in following spray missions, the 10-inch dump valve should be opened to completely drain the tank.

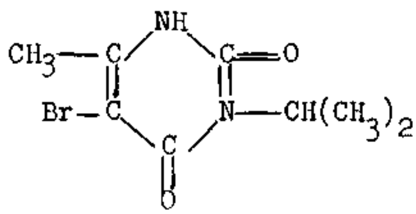
WHITE is a formulation prepared for agricultural use, one gallon diluted with 99 gallons of water. The quantity of surfactant contained in the WHITE is therefore based on this dilution factor. In various aircraft systems, bubbles and foaming and air pockets develop while the agent is being recirculated and sprayed. This is due to the high surfactant content.

WHITE continues to be a problem because of its high viscosity (see the attached Memorandum for Record). The high viscosity of WHITE has resulted in over taxing pump engines which are used to fill the spray tanks in aircraft systems.

The flow rate of most of the aircraft systems in Vietnam yield a 3-gallon per acre deposit of ORANGE with pump pressures of 60 to 80 psi. With WHITE, the engine at full speed will produce a pressure of only 40 to 60 psi. The flow rate is therefore reduced below that required to yield a ground deposit of 3 gallons per acre. Consequently, a single pass with WHITE over a target will not yield 3 gallons per acre and multiple passes will be required. Moreover, at the lower pump pressure and higher viscosity, larger droplets will be obtained which will result in poorer canopy penetration that is obtained with ORANGE. In most systems, it is estimated that only 1½ gallons per acre of WHITE is being dispersed instead of the desired 3 gallons per acre.

Bromacil - Soil Sterilant

Chemical Structure



5-bromo-3 sec butyl-6-methyl uracil

Type of Chemical

Soil sterilant; used for industrial and general vegetation control, particularly on perennial grasses.

Physical and Chemical Properties

Melting point .... 158 - 159 C.
Appearance .... Odorless, white crystalline solid
Solubility @ 25 C. .... in water, 815 ppm. soluble in acetone and alcohol, slightly soluble in Diesel oil
Stability .... fairly stable, not absorbed on soil colloids

Formulation

Bromacil is formulated as an 80%, wettable powder (HYVAR-X), a 50% water-soluble powder (HYVAR-X-WS) and in a liquid formulation (UROX 'B') containing four pounds of active ingredient per gallon.

Toxicity

Easily handled. No evidence of toxicity to humans or animals.

Uses

Bromacil will clear and keep clear vegetation in areas around compounds, minefields, airstrips, ammunition dumps, radar sites, anti-aircraft sites, motor pools, helicopter pads, docks, warehouses, and wire defensive barriers.

Bromacil - Soil Sterilant

Bromacil (known commercially as HYVAR-X) is an all-purpose semi-permanent soil sterilant, particularly effective on perennial grasses. Relatively low rates of application only are required compared to other soil sterilants.

Available as wettable powder (HYVAR-X), water-soluble powder(HYVAR-X-WS) or liquid (UROX 'B') for spray applications. Recommended for areas where aerial spray or ground spray application can be made.

Bromacil is noncorrosive and can be safely used in contact with pierced steel airstrip planking and other metals. It is relatively stable once incorporated into the soil and shows little tendency to wash away in heavy rainfall, so it may be used closer to crop lands than other soil sterilants, topography or drainage permitting.

Water soluble or liquid formulations are more convenient than wettable powders for use in military spray equipment such as the Buffalo turbine and UH-1 type helicopter with the modified HIDAL equipment. Commercial applications of this chemical are normally made at spray volumes of 75 to 150 or more gallons per acre for clearance of rights-of-way, industrial sites, etc. It is suggested that minimum volumes of 30-40 gallons per acre of total solution be used for effective coverage. One and one-half pounds of HYVAR-X-WS can be dissolved in one gallon of water but may require stirring for 30 minutes to one hour.

Mechanical clearing of vegetation by chopping, brush cutting or bull dozing around compounds, ammunition dumps, runway, etc. is not absolutely necessary prior to spray application, but this will facilitate incorporation of the chemical into the soil where it must be to provide maximum effectiveness.

Technical Aspects of Use and Rates

The water soluble and liquid formulations can be used in most application equipment and are noncorrosive to metals. The wettable powder requires agitation during spray release.

As a soil sterilant, Bromacil acts almost wholly by absorption through the root system; it is most effective under conditions of good soil moisture and hence active only during the rainy season; it is best applied early in the growing season.

Bromacil has been proved most effective in the control of perennial grasses. It can also be expected to kill elephant grass and sugar cane. It has been found to be 2 to 5 times more active than associated substituted areas.

Variable effects have been found on woody plants, but the toxic action is not appreciably reduced on heavy soils compared to sandy soils.

Fifteen to thirty pounds per acre of active ingredient are suggested for tropical areas for residual effect. In temperate zones, rates of 10 to 15 pounds per acre are used. This amount of active ingredient may be applied in 30 to 50 gallons of an herbicidal oil (Diesel Oil) per acre for quick topkill of the vegetation. Water may be used as the carrier if quick contact action is not required. Spray concentrations of up to 50 to 150 pounds per 100 gallons of water or oil can be handled by the HIDAL and FIDAL equipment. HYVAR-X is especially suited to ground application methods and equipment such as the power driven decontamination apparatus. The 80% wettable powder formulation requires good agitation while spraying for best results.

Bromacil is relatively slow acting, and effective control can be expected for two years or longer depending upon leaching of the chemical by rain.

COST

$ 5.70 per pound as the 80% wettable powder
$ 3.95 per pound as the 50% water-soluble powder
$39.00 per gallon as the liquid formulation containing four pounds of active ingredient per gallon

Application costs

(rate x unit cost)

HYVAR-X - 80% wettable powder:
15 to 30 pounds at $ 5.70 per pound = $81 to $162 per acre

HYVAR-X-WS - 50% water-soluble powder:
24 to 48 pounds at $ 3.95 per pound = $96 to $192 per acre

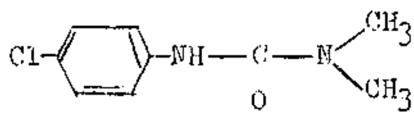
UROX 'B' - 4 pounds per gallon liquid formulation:
3 to 6 gallons per acre at $39.00 per gallon - $117 to $234 per acre

UROX 22 Soil Sterilant

Chemical Name

MONURON
(Telvar R)
= CMU

Monuron trichloroacetate (combination of Monuron and trichloroacetic acid)



Formulations

Urox 22, granular formulation containing 22% monuron trichloroacetate
Urox 11, granular formulation containing 11% active ingredient
Uron emulsifiable concentrate, liquid formulation containing three pounds per gallon active ingredient

Type of Chemical

Soil sterilant, for use on noncrop land

Physical and Chemical Properties

The suggested granular formulation (Urox 22) is prepared as a coarse granule with a strong distinctive odor which persists for several days after application.

Monuron trichloroacetate breaks down in contact with soil moisture to monuron, which has a solubility in water of 230 ppm, and trichloroacetic acid, which is readily soluble.

The material is mildly corrosive to metal in the concentrated form, but is noncorrosive when incorporated into the soil. Equipment should be cleaned and flushed thoroughly with water after use. The material is nontoxic to humans in handling, but may cuase skin irritation in a few sensitive individuals. A respirator or mask may be used in hand broadcasting to avoid inhalation of the fine particles.

Uses

Uron 22 is fairly slow in action and is used as a general soil sterilant for vegetation control in noncrop areas. It is especially effective on annual and perennial weeds and grasses and is effective on woody vegetation at the higher rates. Depending on the use rate in tropical areas, it may last 12 months or more but is affected by the amount of leaching, chemical decomposition in the soil, and microbial decomposition

Rates

One hundred fifty to three hundred pounds per acre of the product (22 percent granules) are recommended by the manufacturer. Two hundred pounds per acre are effective for general warm temperate climates with 40 to 50 inches of rainfall per year.

Cost

Urox 22 is available in 160-pound fiber drums at $0.62 per pound. It would cost approximately $124.00 per acre if 200 pounds per acre was the rate chosen.

Herbicide Decontamination

ORANGE will remove paint and enamel from aircraft surfaces. In addition, contaminated aircraft walkway surface coatings and fabric aileron surfaces will deteriorate. Aircraft tires have proven to be fairly resistant. Rubber products with continuous exposure such as transfer hoses and gaskets will be softened and warped and the rubber soles on combat boots will develop a "sponge rubber" consistency.

Aircraft filling areas, where spillage and runoff occurs should be washed down periodically with soapy water. Runoff should be collected in a suitable area. This waste should NOT be allowed to collect in irrigation or drainage ditches.

At present, there are no chemical decontamination procedures for inactivating ORANGE, WHITE or BLUE.

Normally, contaminated surfaces of spray aircraft should be washed daily with soapy water and/or water with detergent added. If used daily, the spray systems need not be flushed except where the spray solutions are to be changed, especially changing from WHITE to BLUE or BLUE to WHITE, otherwise an undesirable precipitate may be formed in the system.

Herbicides in normal use will decompose in 2-8 weeks in warm, moist soils such as are found in tropic areas. Dry or frozen soils will not decompose the chemical quickly. The herbicides, PINK, PURPLE, and ORANGE do not decompose as rapidly in light sandy soils as they do in heavier soils with a high percentage or organic matter.

Disposal of Herbicide Waste
by
C. E. Minarik

27 April 1967

An on-the-ground survey of the herbicide drainage area at Bien Hoa Air Base was conducted and the problem was discussed with LTC Dennis, Commander 12th Air Commando Squadron (RANCH HAND), on 6, 7, and 14 April 1967.

The area of interest is on the western edge of the airstrip and drains into a marsh which empties into the Dong Nai River which in turn flows into the Nha Be River and finally into the South China Sea.

The area of concern currently is part blacktop, part gravel and part sand or soil. It would appear that if the entire area were paved with concrete (not blacktop) and sloped to direct the spillage, wash water and rain into the marsh creek, this would dispose of the herbicides with little or no hazard to desirable vegetation or fish. The creek is fed by waste water from Bien Hoa Air Base and considerable dilution of herbicides would occur along the way to the sea. The Dong Nai River where the creek empties into it is about seven feet deep and about one-quarter of a mile wide. This large volume of water would dilute the herbicides, rendering them innocuous.

If the aircraft filling area, where spillage occurs and aircraft wash down is carried out, were flushed daily with large volumes of water, no herbicide buildup would occur in the waterways mentioned above or in the soil.

The problem as originally posed envisioned moving the location of the RANCH HAND spray planes to the east end of the airstrip where drainage would carry the herbicides into a stream which flows through a fish hatchery. Currently it is planned not to change the location of the spray planes. However, in the event that a change in location is made at some later date and herbicide disposal should become a problem either at Bien Hoa or Da Nang, there are three disposal methods that may be considered.

1. Excavate an area about one-half to one acre in size and create a pond to hold the spilled herbicide, wash water and contaminated rain runoff. The herbicides in the shallow pond water will gradually be decomposed by ultraviolet light and microbial action. In addition, there will be gradual seepage of the diluted herbicides and decomposition products into the subsoil where they will no longer constitute a hazard to fish or vegetation. The shallow pond technique is widely used in the chemical manufacturing industry to dispose of wastes. Both WHITE and ORANGE are readily decomposed by the ultraviolet light in sunlight. They are also decomposed by soil-borne microorganisms.

Atch 5

2. A second disposal method would involve digging a deep, broad trench or ditch into which the waste waters would drain. ORANGE being heavier than water would settle and would be covered by a layer of water. WHITE and BLUE being water soluble would be diluted by wash water and rain and would leach into the subsoil. ORANGE would also leach out, but presumably at a slower rate. If it were desired to slow the rate of difussion of WHITE and BLUE into the subsoil, one could place agricultural lime in the bottom of the trench. This would form the less soluble calcium salts of 2,4-D, picloram and cacodylic acid and retard their leaching rates.

3. A third method is to cause the waste material to drain into a large reservoir or cistern and then dispose of it through a large drainage field similar to a septic field used in sewage disposal. The drainage field could be near a perimeter or between landing strips where vegetation control was desired.

In general, all three methods involve getting the herbicide wastes below the surface of the soil to prevent runoff in surface water. The herbicide BLUE, Phytar 560G, poses less of a problem than ORANGE or WHITE, since it is strongly adsorbed on the surface of soil particles and is thereby rendered inactive. <u>There are no chemical decontamination procedures for inactivating ORANGE or WHITE.</u>

The following information on the toxicity of 2,4-D for fish may be of interest.

LD_{50} concentration for catfish and minnows is 2000 ppm and for sunfish 1000 ppm. The upper safe limit (LD_0) for minnows is 1500 ppm and for sunfish and catfish, 500 ppm.

One part per million (1 ppm) is equivalent to 2.7 pounds of material per acre-foot of water; thus the amount of 2,4-D required to kill 50% of the catfish in a pond, one acre in surface area and one foot deep is (2.7 x 2000 x 1) or 5,400 pounds.

Attention should also be devoted to reducing the amount of spillage which occurs principally when the herbicides are being transferred from the 55-gallon drums into the 500-gallon tanks. A foot valve in the bottom of the pipe which is inserted into the 55-gallon drum would minimize herbicide drainage when the pipe is removed.

Careful handling of the 'empty' drums will also minimize spilling the 1 to 4 quarts of herbicide remaining in them.

M12A1 Decontaminating Apparatus Now Standard-A in the Army Inventory

The U. S. Army Test and Evaluation Command conducted an integral service test at Dugway Proving Ground, Utah, to determine whether the M12 decontaminating apparatus would be an acceptable replacement for the M9 power-driven decontaminating apparatus (PDDA) as the standard Army decontaminating apparatus (TIP 14-26, March 1966, page 16). The deficiencies and shortcomings encountered during testing have been corrected, and a modified item has been type classified as standard-A with the following designation:

Decontaminating apparatus, power-driven, skid-mounted, multipurpose, nonintegral, 500-gallon, M12A1 (FSN 4230-926-9[illegible])

The M12A1 (fig. 2) consists of a gasoline engine driven pump assembly, a 500-gallon tank unit, and the M2 water heater.

The pump unit is a centrifugal model weighing approximately 1,535 pounds, with a minimum working capacity of 53 gallons per minute (gpm) of STB slurry of 54 gpm of water through the two discharge hoses at a working pressure of approximately 105 psi. The delivery is rated with a pump driven at 4,400 revolutions per minute (rpm). Each discharge hose is provided with a discharge gun assembly that includes special nozzles for STB slurry, fire fighting, and foam operations. These nozzles are identical to those used with the M9 PDDA.

The tank is a 500-gallon stainless steel assembly weighing approximately 996 pounds (empty). The working capacity is 447 gallons of water of 310 gallons of STB slurry.

The M2 water heater is a forced-circulation type heater that operates using gasoline, JP-4, kerosene, diesel fuel, or fuel oils. The unit can heat 600 gallons of water per hour to 100 F. when inlet temperatures are 50 F. ±15 F. (The heater is a separate end item when issued for use with the M12, M9 and M3-series decontaminating apparatuses.)

Other items used with the M12A1 apparatus are:

(1) Antiset, decontaminating slurry, M2 (6850-656-0926).

(2) Antifoam compound, silicone, 8-lb. bottle (6850-950-6489).

(3) Decontaminating agent, STB (6850-297-6653).

(4) Foam liquid, fire extinguisher, 5-gallon pail, type 5 (4210-2[illegible]3-9977).

The M12A1 apparatus may be carried by ground vehicles and by air vehicles, either internally or externally. The components are all skid-mounted and can be carried on the M656 5-ton 8 x 8 cargo truck or on the M35, M135, and M211 2½-ton trucks. The 2½-ton trucks are not as suitable as the 5 ton due to their configuration and limited space. The M656, 5-ton cargo truck, scheduled for initial procurement in FY 67, was recommended to be the prime mover for these skid-mounted units. The U. S. Army Combat Developments Command is to specify the suitable cargo vehicle to be used on a 1:1 basis for all Army units receiving the M12A1. The M12A1 can be air transported by CV-2, CH-37, and CH-47A aircraft. External air transport is possible using an UH-1B, UH-1D, CH-21, CH-34, CH-37, or CH-47A helicopter.

The M12A1 apparatus now becomes a standard-A item for the Marine Corps also; the M12 apparatus remains standard-A for the Navy and the Air Force. The M9 decontaminating apparatus has been reclassified as standard-B. The M12A1 apparatus will replace the M9 apparatus as the M9's become unserviceable. By separate action the M8A2 trailer-mounted apparatus will be obsoleted, thus making the M12A1 unit the only standard-A decontaminating apparatus in the Army inventory.

There are presently six M12A1's with Army units. The Department of the Army authorized prior procurement of these units from the Marine Corps. Two each of these units are located at Fort Bragg, at Fort Campbell, and in the Republic of Vietnam. These units are for use with airborne and airmobile divisions. It is projected that 53 M12A1's will be procured in FY 67 in accordance with AMP schedules.

Overall evaluation indicates that the M12A1 PDDA provides a versatile and highly adaptable unit that will meet normal and large area decontamination requirements. Secondary usage is for field showering of personnel, pumping water, cleaning vehicles, de-icing, and assisting in normal fire-fighting operations. If the prime mover becomes inoperative, the unit can be transferred to another vehicle.

Initial basis of issue of the M12A1 will be as follows:

TOE	Unit	Qty
33-7E	Cml Direct Spt Co	10
3-147E	Cml Gen Spt Co	5
3-217E	Cml Decon Co	12
3-500E	Cml Svc Org	6
9-17E	Ord Ammo DS/GS Co	1
11-216F	Hq & Hq, Sig Bn, Abn Div	1
11-500D	Sig Svc Org	1
17-52E	Hq & Hq Tp, Armd Cav Regt	1
29-11E	Spt Comd, Inf Div (Mech)	3
29-21E	Spt Comd, Armd Div	3
29-27E	Fwd Spt Co, Maint Bn, Inf Div (Mech)	1
29-37E	Fwd Spt Co, Maint Bn, Armd Div	1
29-114F	Fld Svc GS Co, Fwd	4
29-124F	Fld Svc GS Co, Army or ComZ	4
29-136F	Hq & Hq Det, GS Maint Bn, Army or ComZ	4
29-137F	Hvy Equip GS Maint Co, Army or ComZ	1
29-139F	Coll Class & Salv Co	1
29-216F	Hq & Hq Co, Sup & Svc Bn, DS	3
29-307D	Spt Co, USA Msl Comd, Air Tr	1
29-51F	Spt Comd, Abn Div	1
29-57F	Gd Maint Co, Maint Bn, Abn Div	1

TA	Unit	Qty
3-2	USA Cml Ctr & School	18
9-2	USA Ord Ctr & School	1
50-413	Pine Bluff Arsenal	1
50-447	Edgewood Arsenal	18
50-456	USA Bio Labs, Ft. Detrick	3
50-732	USA Arctic Test Ctr	1
50-747	USA Tropic Test Ctr	21
50-772	Dugway Proving Ground	15
50-800	Anniston Army Depot	2
50-826	Tooele Army Depot	3
50-945	USA Staging Sta	1
74-5	USA Caribbean (Panama & Antilles areas)	1
77-9	Seventh Army, Opns	35
80-10	Eighth US Army	4
82-5	US Army, Hawaii	2

Appendix A. GLOSSARY

AEROSOL - Consists of a solid, or a liquid, not vaporized, but divided into particles small enough to float in the air for extended periods of time. (A vapor is the gaseous form of any substance that is normally a solid or a liquid.

CUTANEOUS - Affecting the skin.

DOSAGE - A measure of the amount of agent in a given volume of air to which plants are exposed for a period of time.

DOSE - The amount of agent that is taken into or absorbed by the plant.

HECTARE - 10,000 square meters, or 2.471 acres.

MICRON - A unit of measurement equivalent to 0.001 millimeter or about 1/25,000 of an inch. Symbol = μ.

HERBICIDE - Any preparation used to kill or inhibit the growth of plants. Includes defoliants, dessicants, plant growth regulators, and soil sterilants.

HERBICIDE OPERATIONS - The employment of herbicides in tactical or strategic operations.

Appendix B. HERBICIDE DISPERSERS

Disperser	Capacity (gallons)	Discharge Rate
M106 riot control agent disperser (Mity Mite)	3	---
M12A1 power driven decontamination apparatus (PDDA)	500	---
Buffalo Turbine	100	---
Hand-pump sprayer	3	---
HIDAL (Helicopter Insecticide Dispersal Apparatus, Liquid)	196	70+ gal/min.
FIDAL (Fixed-wing Insecticide Dispersal Apparatus, Liquid)	285*	---
A/A 23Y-1 A/A 45Y-1	975	UC-123B --- 275 gal/min.

* Per tank - 3 tanks per A1 series aircraft - flow rate adjustable.

NOTE: Agricultural Aviation Engineering Company, P. O. Box 5054, McCarran Airport, Las Vegas, Nevada

Appendix C

ANTIPLANT USE RATES PER ACRE

Vegetation Type	ORANGE, PURPLE, PINK (Agents)	WHITE (Agents)	BLUE (Phytar 560G as is or dry powder @ 5 lbs/gal)
Mangrove	1.5 gal/acre	3-5 gal/acre	2 gal/acre
Highland trees (jungle)	3.0 gal/acre	3-5 gal/acre	2 gal/acre
Mixed Mangrove and other trees (lowland swamp)	3.0 gal/acre	3-5 gal/acre	2 gal/acre
Broadleaf crops (bean, manioc, banana, corn, tomato, etc.)	1.0 gal/acre	3-5 gal/acre	2 gal/acre
Rice	5.0 gal/acre	3-5 gal/acre	1 gal/acre
Mixed vegetables and rice	3.0 gal/acre	3-5 gal/acre	2 gal/acre

For defoliation use, ORANGE, PURPLE, and PINK may be diluted with No. 2 Diesel fuel oil at a 1:1 or 1:2 rate to insure adequate droplet coverage of the target vegetation.

Appendix F. CONVERSION FACTORS

DISTANCE:

1 Meter	=39.4 inches
	= 3.3 feet
	= 1.1 yards
1 Mile	=5280 feet
	=1760 yards
	= 1.6 kilometers
1 kilometer	= 0.6 miles

WEIGHT:

1 pound	=16 ounces
1 kilogram	= 2.2 pounds

VOLUME

1 gallon	=4 quarts
	=8 pints
1 liter	= 1.06 fluid quarts

SPEED:

1 knot	=1.15 miles/hour
	=1.85 kilometers/hour
1 mile/hour	=1.47 feet/second

AREA:

1 square meter	=10.8 square feet
1 square foot	=144 square inches
1 square yard	= 9 square feet
1 acre	=0.4 hectares
	=43,560 square feet
1 square kilometer	=1,000,000 square meters
	=100 hectares
1 hectare	=10,000 square meters
1 square mile	=2.6 square kilometers
	=640 acres
	=259 hectares
Kg/ha x 0.892	=lbs/A