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U.S. ARMY CHEMICAL CORPS RESEARCH AND DEVELOPMENT COMMAND
U.S. ARMY BIOLOGICAL LABORATORIES
Fort Detrick, Maryland

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4B11-01-004, Anticrop Warfare Research, Task -01. The
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J. W. Brown

Crops Division
DIRECTOR OF BIOLOGICAL RESEARCH

Project 4B11-01-004

April 1962

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ABSTRACT

A variety of defoliants and vegetation killers were tested in South Vietnam to evaluate their effectiveness in denuding jungle growth. Both recognized and unidentified species of grasses, shrubs, and trees were sprayed from the air or with ground equipment. Results were recorded in color photographs. Effectiveness varied from poor to excellent. Controlling factors were limited equipment, low dosage rates, and meteorological conditions.

The work is recorded in two volumes, of which this is the first. The second, "Vegetational Spray Tests in South Vietnam, Supplement," is classified (52-FDS-834).

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FOREWORD

Instructions for the preparation of this report included the requirement that only one of the two areas of effort (Task 20 and not Task 2) in Free Vietnam should be reported. This has been done; however, not all of the pertinent documents on Task 20 are available to the author, and many documents that are included contain material pertinent as well to Task 2. In order to make the record as complete as possible, all available pertinent documents have been included in the Supplement to this report, although they may refer to Task 2 as well.

Jungle, roadside, and swamp vegetation offer areas of concealment to terrorists in Free Vietnam, allowing them to establish bases hidden from aerial observation, and to ambush friendly traffic along roads and waterways. Defoliating the vegetation or killing it could improve the observation of such areas.

A satisfactory universal defoliant remains yet to be discovered. Because known chemicals have been used for several years to kill various kinds of vegetation in the US, chemicals of this type, immediately available in quantity, together with candidate defoliants or desiccants, were tested in South Vietnam to demonstrate what could be achieved on the botanically unknown species of that country.

This report concerns the work performed by the writer in South Vietnam under the auspices of OSD/ARPA during two periods, mid-July to mid-November, and mid-December 1961 to mid-February 1962. Because of the urgency that this effort be of assistance to South Vietnam, both the disseminating hardware and the chemicals had to be those immediately available. ARPA was informed before the writer went to Vietnam in July that the killing action of the chemicals to be used for aerial sprays was not particularly rapid, requiring weeks rather than days for maximum effect. They indicated that time for effect was not critical.

In regard to Task 2, the demonstrations performed in that task were immediately accepted by the VN and US alike. Both Tasks 2 and 20 were performed under the strictest security conditions. Operational personnel accordingly could have been inadequately informed on the technical requirements of these tests.

Because of the urgency associated with the preparation of this report, several people have been involved and their assistance is gratefully acknowledged:

Dr. Charles W. Beard
Mr. Lester W. Boyer
Mr. Robert K. Castle
Colonel Carl S. Casto

Mr. George A. Evans
Dr. Robert J. Goodlow
Mr. A. E. Hayward
Mr. Kent R. Irish

Mr. William B. Johnson
Dr. C. E. Minarik
Major James W. Startt
Mrs. Carolyn M. Walker

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DIGEST

This report sets forth in detail the vegetational spray tests performed under the auspices of OSD/ARPA in Free Vietnam and presents illustrations of the results achieved. In the performance of these tests several aerial spray systems and a ground system for roadside sprays were utilized with varying degrees of success. These systems had not been previously calibrated for spraying the chemicals, which were not only of greater viscosity but required higher flow rates than those liquids normally sprayed by these systems for other purposes.

The chemicals used and those ultimately recommended (purple, pink, and green) for larger-scale use are plant-growth regulators known to be effective in killing many US species, including trees and brush, and are commonly used in the US for this purpose and for weed control in agriculture.

The great majority of tree species encountered in Vietnam are unknown and remain to be identified. Because species of plants are known to vary in their sensitivity to these chemicals, it was necessary to test each chemical against these unknown species and ascertain a suggested use-rate to achieve a useful killing effect. Ultimately, this was to provide increased visibility in jungle, mangrove, or roadside areas.

For greatest and most rapid effect, vegetation should be in a stage of active growth. Good coverage, including penetration of the foliage with sufficient chemical, is mandatory. Under these conditions, it is estimated that two to six or eight weeks are required for the death of susceptible species, depending upon their sensitivity, and that generally 70 per cent or more of the forest stands at the various test sites are capable of response.

Most aerial releases were performed with the C-47 spray rig, which was the only aerial system available for an extended period. Unfortunately, it was the least suitable system; it consistently failed to achieve sufficient flow rates and deposited sublethal amounts of the chemicals even though it was functioned at maximum pressure. This pressure probably made the spectrum of particle sizes in the spray smaller than desired and under lapse or neutral atmospheric conditions could have contributed to excessive spray dissipation. An unequivocally successful test with this equipment at tree-top level under inversion conditions near the Bien Hoa airstrip in October substantiated the equipment limitation and confirmed chemical effectiveness. With relatively minor re-engineering, it is believed that this system could be satisfactorily improved for this spray purpose.

These tests were performed under conditions of great security consonant with VN requests and US agreement, and information concerning them was disseminated on a very strict need-to-know basis. Later, when large-scale

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operational testing was initiated and conducted by USAF, too few people were cognizant of all technical requirements. Those that were cognizant could be heard only incompletely or lacked authority for insuring technical compliance.

The equipment used in the USAF tests was used for the first time for spraying chemicals to kill vegetation. There was insufficient time to get the equipment checked out for spraying these chemicals and needed adjustments were made on the basis of the results of spraying the first USAF targets on 13 January 1962. Complete calibration of the equipment for spraying these chemicals is essential for the most efficient effect.

The majority of the aerial spray tests were performed during the period August to October, 1961. The results obtained varied from relatively poor to very good. In this period the least impressive results were associated with equipment limitations rather than with a lack of vegetation response to the chemicals. Unfortunately, the USAF spraying did not get under way until the middle of the dry season, which in upland areas markedly curtails active growth, a condition preventing expression of the chemical effects.* In mangrove areas, where water was plentiful for growth, visibility was markedly improved in one month's time. ✓

* NOTE: A message from COMUSMAC Vietnam to CINCPAC dated 23 March 1962 demonstrates the efficacy of the USAF tests in spite of the technical problems encountered. The text of the message is published as Section I of the Vegetational Spray Tests Supplement (62-PFS-834).

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I. BACKGROUND

A. TECHNICAL PROBLEMS

On approximately 10 days' notice, the author went to South Vietnam to conduct tests in connection with Tasks 2 and 20, which were already set up in the joint program of the MAG R&D Division and the VN Combat Development Test Center (CDTC). For these tasks the assistance of Mr. W. B. Johnson was requested for the initial phases of the work, and that of Mr. L. W. Boyer for the latter phases. The time periods on location for each of the above were:

	Arrived	Departed
J. W. Brown	17 July 1961 14 December 1961	14 November 1961 16 February 1962
W. B. Johnson	17 July 1961	12 September 1961
L. W. Boyer	10 October 1961	2 February 1962

At the outset, demonstrations were to be performed with chemicals and spray equipment immediately available and time for effect of the chemical spray was indicated to the writer as not being critical.

U.S. military research in defoliation has been unfunded since FY 1958. Therefore, although today there are chemicals of promise in causing defoliation, the urgency of the situation in Vietnam practically dictated our using only those chemicals for test that had had considerable research, proven performance, and practical background. Also, other factors had to be considered, such as availability in large quantity, costs, and known or proven safety in regard to their toxicity to humans and animals if a scale-up of spray use should be required. The chemicals selected for test should be considered not necessarily as "defoliants" but as vegetation control chemicals that are effective in killing susceptible species. Additionally, it was believed that killing the vegetation would achieve a more lasting effect. See Section II of the Vegetational Spray Tests Supplement (62-PDS-834).

In general, all the available spray equipment had been designed primarily for spraying chemicals or materials with physical characteristics (including lower viscosity) different from the test chemicals. Moreover, the equipment had to be assembled on location and tested functionally prior to spraying chemicals that had been selected for vegetational tests. For the assembly, installation, and functional testing of a 675-gallon C-47 spray rig, a 90-gallon 148 spray tank mounted on an AD6, and a 200-gallon Helicopter Aerial Dispersing Apparatus Liquid (HIDAL) mounted in and on an H-34, the assistance of the following specialists was essential:

Sgt. James McIntosh, USMC Ser. #1458 145894 MOS 6311
T/Sgt. Leon O. Roe, USAF, AF 6969313

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Another piece of equipment, a 100-gallon "Buffalo Turbine," was also assembled and functioned. This equipment is mounted on a single axle and can be towed for ground operation, or it can be loaded onto and functioned from a 2½-ton truck bed. The HIDAL was functioned first on 10 August, the C-47 on 24 August, and the 14B on 25 August, all using Dinnoxol, a commercial preparation of 2,4-D and 2,4,5-T growth-regulator vegetation killers. The Buffalo Turbine was functioned with Dinnoxol on 18 September.

It was originally intended to provide the Vietnamese (VN) with a spray capability with the C-47 spray rig and with the Buffalo Turbine; the other units were to be only for loan or demonstration (See Section III of the Supplement). It was essential for VN pilots to be instructed in aerial spray techniques if they were to fly C-47 spray missions. To provide this instruction, Captain Mario D. Cadori, USAF AO 936686, was assigned on TDY, but only after the writer refused to take the responsibility for the safety of the VN flyers and the equipment if they were denied this instruction. This special kind of flying is beyond doubt hazardous, and Capt. Cadori accomplished a very difficult task of instruction in an outstanding manner.

Unfortunately, high hopes were placed on the usefulness of the C-47 spray equipment because it had the greatest capacity and it was used for most of the test spray releases. However, the spray results using this rig were the least impressive of any of the aerial systems employed. Section IV of the Supplement to this report discusses the shortcomings of the C-47 spray system. Yet it was the only system available for conducting the subsequent aerial tests, because after the H-34 test spray of 10 August using the HIDAL, this system was grounded (in the US as well) until a "fix" was available and was not functional again until 12 January 1962. The 14B/AD6 system was dismantled and returned to the USMC according to plan after its demonstration flight. The C-47 system should not be condemned wholly, for it is believed that with relatively minor re-engineering it could be adapted for spraying these more viscous materials. It appears that first steps to improve its use for this purpose would include more suitable nozzles, a pump of greater capacity, and piping to allow greater flow rates with less pressure drop. The inclusion of a flow meter in the system is desirable where solutions of different viscosities are to be sprayed. It is not known, however, whether the facilities and materials in Vietnam are adequate to accomplish these steps, simple though they may sound. Capt. Frank Dowell, USAF, 2nd ADVON, is the best authority on the necessary changes to this equipment, including the requirement for calibration of the altered equipment. The latter requirement applies also to the C-123 equipment; that is, it also needs calibration.

Because it takes two to six weeks or more for peak effectiveness to show as a result of spraying these chemicals, and the time required is dependent on several factors, the deficiencies of the use of the C-47 rig were not readily apparent. In the minds of many, the chemical effectiveness

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was suspect. There were, however, successful tests with the HIDAL (Test 1), the 14B (Test 3), and the Buffalo Turbine (Test 9), which indicated that the use of the C-47 rig (Tests 2, 4, 5, and 6) left something to be desired.

Several factors came to light on examining the C-47 rig and its history:

(a) The system had been designed to spray insecticide solutions of lesser viscosity than that of either Dinoxol or Trinoxol, which were of about similar viscosities.

(b) For normal use of the system in the US, a deposition rate of about 1/3 of a gallon per acre is desired, whereas, with the vegetation killers at least 3 times this amount was sought.

(c) For its normal use in the US, a mass median particle diameter of about 65 microns is useful in area coverage work where aimability of the spray is not a stringent requirement. For vegetation killers a spectrum of particle sizes ranging from about 50 to 250 microns was sought, but it was necessary to use the nozzles originally selected for spraying insecticide.

(d) In its normal use in the US, an effective swath of about 300 feet was assumed, and this swath was assumed for the spray of vegetation killers.

(e) Because of factors beyond control, the sprays were not always released under inversion conditions.

(f) Efforts to obtain increased flow rates to satisfy (b) above apparently aggravated the situation, because particle sizes already small were made smaller, so that dissipation of the spray was increased, especially if the release was not made under inversion conditions.

As a result of this examination, it was concluded that sufficient chemical was not being deposited on the test vegetation with this equipment.

An effort was made to confirm this finding by the three swaths that were sprayed near the Bien Hoa Airport on 17 October. The pump pressure was maximum (30 psi vs 20 psi); the altitude of release was requested at 25 feet (intended to be above the tree tops, but the VN pilot misunderstood and clipped tree tops with the propellers); the most appropriate chemical left in sufficient quantity at this time, Trinoxol, was used; the spraying was done under inversion conditions at about 0845 in the morning; the easternmost swath was sprayed twice to achieve a double dose. Photographs (Test 7) show the spray delivery and lasting effect. There is little evidence that the swath that was sprayed twice showed more effect than those with a single spray. It is possible that regrowth may not occur as rapidly in this swath, but all swaths appeared about the same three months later without obvious regrowth. (In the photographs, the green vegetation

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apparent in the center of each swath is the unsprayed area that was directly below the fuselage of the C-47 when it was spraying at the very low altitude. The spray booms and nozzles are located under each wing of the C-47.)

The test site near Chon Thanh was a roadside site that was the first sprayed with Dinoxol by the C-47 rig on 24 August. It was planned to spray by 0900 hours, but difficulties and delays encountered by the ground party in driving to the site delayed the spraying until 1030, with a consequent loss of inversion conditions. The modest security guard was increased en route to about 60 armed soldiers and 5 armored cars as we neared the site. It was learned later that a VC (enemy) ambush had occurred two days prior to spraying at the very kilometer marker (No. 76) used for one end of the test runs. The concrete marker itself had been moved by the VC to the middle of the road to block traffic, and foxholes were evident on either side of the road. This site was four kilometers long on both sides of the road, 76 to 80 kilometers almost due north from Saigon. This test site was selected personally by President Diem. Reports from the Kontum area, where successful roadside sprays with HIAL were performed 10 August, may have been available to him, but this is not known to the writer.

B. WORKING CONDITIONS

With the relatively short notice available for the trip to Vietnam, but little indoctrination was possible and consisted in the main of quickly reading "The Ugly American" and attending for one afternoon two scheduled presentations at the Military Assistance Institute. Perhaps this was adequate under the circumstances, since there was precious little time to grasp even the rudiments of the language. The language difficulty was most apparent initially, and it is suggested that anyone who takes the trouble to learn some Vietnamese and use it will receive the respect of the VN perhaps somewhat sooner than he ordinarily would. They accept this as a high compliment and a rarity, for so few Americans speak their language.

In a MAAG brochure for those assigned to Vietnam there appears the following well-written and meaningful paragraph:

"YOU AND VIETNAMESE PUBLIC OPINION. The over-all opinion of United States held by the people of foreign lands is of tremendous importance to our country, our nation's objectives, and the future of the Free World. This opinion is developed primarily, not by government directives or announcements, but by individual impressions gained by these people through their contacts with individual Americans. Therefore, you, and all other Americans who come to Vietnam, play a most important part in the furthering of our national interest, over and above the official tasks you perform, simply through your day-to-day contact with the Vietnamese. You will find them friendly and courteous, interesting and congenial, and you will probably

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makes some very fine friends during your stay in Vietnam. It is hoped that you will go more than half way in developing these friendships and that in your contacts with the Vietnamese people you will be guided by the realization that common decency, patience, understanding, politeness and sincerity are qualities appreciated the world over. A smile means the same thing in all languages."

In regard to the above paragraph, it is in a sense regrettable that such a paragraph was deemed necessary in the first place. In the second place, if it was read, it very apparently was not only easily ignored, but individual behavior was obviously contrary to its message. In the third place, those who attached importance to its content and made an honest effort to comply with its intent were often held in suspicion, which on occasion approached ridicule and contempt, by those in the second category.

The Vietnamese have a respect for age, corpulence, higher education, intelligence, sincerity, friendship, and "face" that seems incomprehensible to many Americans, but this is their way of life. Those Americans in VN having any of these qualities, attributes, or characteristics have that much in their favor to establish good relationships with the VN with whom they work. However, if a sincere effort is not made or, conversely, little or no respect is shown the VN, there suddenly becomes little or no workable relationship. It appears that good relationships, mutual respect, and understanding have to be established first before real progress in the job can be achieved, but once this contact has been made and continually strengthened, the progress accelerates rapidly.

It is noteworthy that the VN refer frequently to their "friends" but rarely mention "enemies" as such - they are just not-friends, and among the VN a friend is one of whom drastic demands can be made, frequently on short notice, with the complacent knowledge that the matter is in good hands and will be handled as expeditiously and completely as possible under the circumstances. If it is not, it is understood and accepted that it was not possible. The title of "friend" conferred on anyone by the VN thus carries a connotation that is not immediately apparent to Americans, even though it may seem the word is used rather freely by them. These strong friendship ties seemingly exist throughout the VN military structure and in instances are a most expeditious means of fulfilling urgent, legitimate demands, requests and the like within hours or days via telephone whereas weeks or months would be required through ordinary channels. Or a paper request may be "lost" if it requires the concurrence of one who is not a friend - again a way of life perhaps developed to a high degree in the interest of necessity while the French dominated the military system.

When the writer arrived in Vietnam in mid-July with Mr. Johnson there were some 60-odd projects or tasks already in the joint program of the R&D Division (US) and Combat Development Test Center (CDTC-VN) that had been initiated in June 1961. Two of these tasks were pertinent to the writer's field of endeavor, and he was to function as the US Advisor for these tasks.

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It has been requested, however, that this report concern only Task 20. At that time about three or four other tasks were activated or about to be. The R&D Division in mid-July consisted of five people, four officers and one enlisted man. The facilities were two small adjoining rooms, two office desks, two office tables, five chairs, a typewriter, two telephones, a file safe, and a big program.

A VN Colonel (Colonel Trach) had been assigned as Chief of the CDTC and two VN Captains (Captains Khoat and Chan) were on loan to him. There was no facility assigned as yet to the CDTC. The Colonel spoke Vietnamese, French, and, thirdly, English. Captain Khoat spoke Vietnamese, French, and English rather well, and served on many occasions as an interpreter. He was on loan from VN J-3. Captain Chan was on loan from Ordnance. He spoke Vietnamese and French very fluently, having studied for six or seven years in France, where he obtained a Master's degree in Chemical Engineering. He understood English if it was spoken slowly and clearly but hesitated to try speaking English for about the first ten days to two weeks of our acquaintance.

That the work reported was accomplished at all is due largely to the high level of cooperation and support supplied by the Vietnamese. Colonel Trach and his staff of Captains Khoat and Chan gave immediate attention to the problems and arrangements necessary for the execution of the tests. Captain Chan was the VN project officer for the work and did an outstanding job in helping to expedite its completion. Later, Captain Ton was assigned to assist Captain Chan and many difficult arrangements were performed by him. In instances where neither of these captains was immediately available, Captain Khoat was always helpful in attending to the requirements of the assignment.

These officers always showed the inherent friendliness of the Vietnamese toward me. Communication was not always easy in the early stages of our relationships because of my inability to speak languages better known to them. Also, their inherent politeness toward a "guest" of their government made it difficult to know the extent of understanding achieved, especially when they would tend to say "Yes" to everything the "guest" said. The writer was acutely aware of having to speak with them in English and appreciative that this was perhaps the least fluent language of the several they spoke. This was made known to them very early in our acquaintance, along with the importance of understanding, and they were invited to ask questions or have me explain as slowly, clearly, or thoroughly as they desired until the subject at issue was understood beyond doubt. It was useful several times to write out key words to clear up misunderstood pronunciation.

The very great interest shown by the VN in our work contrasted strangely with that shown by the US side in Vietnam as I saw it, especially in the July-September period. In fairness, the R&D Division was sorely overworked and undermanned to handle administrative matters alone, and those assigned to R&D tasks had their hands full with problems of their own. Also, the VN

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requested utmost security (See Section V of the Supplement) in our work. The result was that, when the time came to consider expansion of the effort, very few people outside of the MAAG R&D Division were really informed of the complexities and requirements involved. Of course, monthly reports, progress reports, trip reports, and memoranda were available to provide background information to those having a need to know (several of these are not now available for use in preparing this report). The breadth of dissemination of this information is not known, because information has a way under these circumstances of travelling vertically with little lateral spread.

Another obvious difficulty was that only a very few who had some knowledge of various botanical sciences could appreciate the information available. In this particular field the entire Department of Defense had only two scientists considered qualified to tackle these problems, Dr. Mirarik and me, both from the same office. So the source of the information in Vietnam was one person, and in its progression through channels oral information could have suffered considerable misinterpretation in relatively short order. As others came into the picture, they too may have had to supply information on short notice. In the latter phases (during December to February) it is possible that several sources were supplying opinions with little relation to fact, thus leading to a state of confusion. A simple point, such as time for effect to reach a maximum after spray deposition was difficult for many to understand and led to prejudgment and condemnation after a single premature observation. Another case, reduced to its simplest terms, was the assumption by others that, because the aircraft had released the spray, a lack of response justified an automatic condemnation of the chemical, ignoring the fact that a sublethal deposit had resulted that could have been due to any one of several things, such as excessive altitude and airspeed of the aircraft, inadequate flow rate (which was maximum for the system), lack of inversion conditions causing spray dissipation, or insufficient canopy penetration due to improper particle size and the fact that the equipment had never been calibrated with the liquids being sprayed. The assumption was inherent that all experiments must be successful—an odd approach to research, to say the least. That three of the first four tests with different equipment were considered successful (Tests 1, 3, and 9; Test 2 was the exception) was almost ignored by those who chose to concentrate on the results of Test 2 and subsequent inadequate tests with the C-47 equipment, the performance of which left much to be desired.

Consider for a moment a system, two identical buckets with a nail hole the same size in the bottom of each. Fill one with kerosene and the other with the same volume of a more viscous liquid such as S.A.E. 30 engine oil (or even liquid glue, to make the point). Which will drain first? This is essentially the viscosity problem encountered with the C-47 spray rig in trying to obtain a flow rate to give adequate deposition.

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In regard to the "atmosphere" surrounding this work, the following extract is deemed appropriate. It is particularly noteworthy that it is of Russian origin.

Extract from DAILY REPORT, USSR & East Europe, 6 March 1962
No. 45 -- 1962

DOGMATISM IN RESEARCH METHODS SCORED

Moscow LITERARY GAZETTE. 24 February 1962--A

(Article by Prof. V. V. Parin, member of the Soviet Academy of Medical Sciences: "The Authority of Facts")

(Summary) Never in the whole history of science has there been such a period of tumultuous development as now. The traditional concepts of the world are breaking down under the impact of new theories, and it is a single generation of men that has to digest all the changes. To some people, however, the nullification of views cherished for many years comes as a fearful shock. They had been admitting a single scientific approach and corroborating it not with the results of their own experiments, but with quotations from the works of predecessors. In this lay the chief harm of the personality cult in the sphere of science: that one particular school of thought was held to be the sole receptacle of truth. Yet such a slavish inertia is contrary to the spirit of dialectic materialism, which admits no such bounds to knowledge.

.....

I have dealt in some detail with the position in physiology and in medicine. However, the problem of the struggle against dogmatism, of a proper approach to the scientific heritage, of keeping up a healthy and genuinely creative atmosphere, is not a physiological or biological problem; it is a general one. It should agitate and it does agitate people working in various spheres of the natural, precise, technological sciences as well as the humanities.

The time is coming when the young generation which we ourselves are educating will take our place. But to teach people the methods of experimental work, of mathematical calculations, and of analyzing the facts gathered is only half the task. Thinking methods which we must inculcate in our pupils must be based on high ethical principles. Genuine science boldly advances into the uncharted fields, constantly developing the tools and methods of research. It never hides behind the authority of great leaders of either today or tomorrow. The truth is always born in a struggle of opinions, in hot creative debates.

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For the sake of the truth, a scientist must be able to drop his own views, no matter at what cost they have been acquired. They must not be stayed by force or by administrative influence, for in this case, a personal collision threatens to grow into a social one. Science breathes only one kind of air—the oxygen of facts. New research methods are the trees cleansing the atmosphere of the carbon dioxide of newly revealed, realized, and understood phenomena. A healthy atmosphere is incredibly important to science. It is not in vain that the greatest of the documents of the epoch in which we are living explicitly refers to this creative atmosphere.

Because the above was written for Russian consumption, the writer suggests a rewrite for the first two sentences of the last paragraph:

"For the sake of the truth, a scientist must be able to change his own views, regardless of the consequences. He must not be swayed by force or by administrative influence, for in this case, a personal collision threatens to grow into a social one." The statement: "A healthy atmosphere is incredibly important to science" bears repeating for the consideration of those administering programs of science. It is difficult enough to search out the truth and advance science even in a free atmosphere uncluttered by preconceptions, misconceptions, misunderstandings, and misrepresentations by others.

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II. CHEMICALS FOR TEST

Many factors were involved in the use of chemicals in this instance. Only certain chemicals were immediately available in quantity to be operationally useful in defoliating or killing jungle vegetation. The country is actively fighting communist aggression where the jungle foliage is used by the enemy to conceal their bases and to ambush traffic along roads and waterways. There is an urgent need to suppress communist terrorism. The standards of living of much of the population may be classed as primitive. Under these conditions, requirements in addition to effectiveness of the chemicals on vegetation include:

(a) The chemicals must be nontoxic to humans in handling, in exposure to dissemination by air or ground equipment (either by direct contact or by the respiratory route), or in the consumption of edible produce.

(b) The chemicals be compatible with the equipment for dissemination, i.e., noncorrosive, noninflammable, etc.

(c) The chemicals have physical characteristics that allow them to be disseminated by available equipment so that sufficient quantity can be deposited on the vegetation without undue dissipation or evaporation. In addition, they must present no unusual or difficult storage, handling, or mixing problems; these include crystallizing at temperatures likely to be encountered in storage or in flight, leaving residues to clog a spray system, or exceeding the facilities available for any mixing required.

(d) The use rate should be as low as possible for effect.

(e) The cost should not be prohibitive.

Allowing for the above criteria, commercial concentrates of 2,4-D and 2,4,5-T were used to provide demonstrations of effect (Table I).

This approach was considered to provide the most direct route to operational usefulness and aid to the Vietnamese consistent with the prevailing urgency. These chemicals have been known and used in the US for more than 15 years, are considered safe to animals and humans, and otherwise meet the requirements above. Additionally, in 1959 chemicals of this type were used successfully to kill the trees growing in an area of about four square miles in an impact zone at Camp Drum, New York. Section VI of the Supplement is a summary report of the work at Camp Drum.

Another approach could have been micro-testing on small plots with numerous candidate chemicals that had far less background for meeting all the requirements. Sixteen of these candidate chemicals were on hand in quantities ranging from grams to gallons. Costs, lead times for quantity

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TABLE I. CHEMICALS TESTED

Color Code	Chemical	Commercial Name	Quantity	Received	Disposition
-	{ 20% 2,4-D butoxy ethanol ester 20% 2,4,5-T butoxy ethanol ester }	Dinoxol	500 gallons	17 July 61	Exhausted 12 Jan 62
-	40% 2,4,5-T butoxy ethanol ester	Trinoxol	535 gallons	4 Sep 61	Used 385 gallons; 150 gallons to VN Jan 62
-	30% 2,4-D ethyl ester (water formulation)	Conc. 48	500 gallons	4 Sep 61	Used 100 gallons; 400 gallons to VN
Pink	{ 60% isobutyl ester 2,4,5-T 40% butyl ester 2,4,5-T }	-	-	20 Nov 61 9 Jan 62	-
Green	100% butyl ester 2,4,5-T	-	-	20 Nov 61	-
Purple	{ 50% butyl ester 2,4-D 30% isobutyl ester 2,4,5-T 20% butyl ester 2,4,5-T }	-	-	partial shipment 9 Jan 62	-
Blue	65% cacodylic acid	Ansar	-	20 Nov 61	-