OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

05056

United Nations Industrial Development Organization

Distr.
LIMITED
ID/WG.154/15
11 May 1973
ORIGINAL: ENGLISH

Workshop on Pesticides
Vienna, Austria, 28 May - 1 June 1973

PATTERNS AND PROBLEMS OF DDT FORMULATING, STORAGE AND USE IN DEVELOPING COUNTRIES 1/

by

Max Sobelman
Montrose Chemical Corporation of California
Torrance, California, USA

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.73-3792

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

1. I'm sure there are many of you here today better equipped than I to discuss the general trend in DDT use among the developing countries. It seems appropriate nevertheless, to devote a little time to this, as well as to say a few words about DDT use in the U.S.A. and about the hearing that preceded the virtual ban that became effective January 1 of this year. The World Health Organization and the Food and Agriculture Organization have provided estimates of DDT requirements in health and agriculture to cover world needs over the next ten years, and I will go into this later. Need and use, as everyone here, I believe, is aware, are not synonymous. Developing countries need more pesticides and fertilizers than they actually use. It is the lack of financial resources that generally determines the size of the gap.

2. In the U.S.A. total annual production of DDT reached a maximum of 179 million pounds in 1963. At that time there were six producers. For the last two years Montrose has been the only basic producer in the U.S.A.

3. Starting in August 1971, a 7-months long DDT hearing conducted by the Environmental Protection Agency was held in Washington, D.C. At this hearing 125 scientists gave testimony that filled 9,300 pages of transcript. 365 scientific documents were submitted in evidence as exhibits. The story of these hearings and their implications are too long to discuss here. It is nevertheless, a fascinating story, because for the first time the many and often sensational claims about DDT's effects on human health and the

environment were subjected to cross examination.

4. At the end of the Hearing, the Examiner, an appointee of the Environmental Protection Agency ruled, and I quote directly from his report, pages 93 and 94:

> 9. DDT is not a carcinogenic hazard to man.
> 10. DDT is not a mutagenic or teratogenic hazard to man.
> 11. The uses of DDT under the registration involved here do not have a deleterious effect on freshwater fish, estuarine organisms, wild birds, or other wildlife.[1]

5. Nevertheless, the Administrator of the E.P.A. reversed his own Hearing Examiner, and banned, as of January 1, 1973, essentially all uses of DDT in the U.S.A., the minor exception being its use as an emergency health measure.[2] I should add, however, that only last month the total ban was lifted to permit the emergency use of DDT on peas for the control of the pea leaf weevil in the Northwest part of the U.S. At the moment an appeal to reverse the ban is pending in the Court of Appeals in Washington and a decision may be expected in the next two or three months.

6. I hasten to add at this point that at no time before, during or after the hearings was the manufacture or export of DDT an issue. With the evident and expressed need for DDT in many parts of the world, we at Montrose are confident that we have the know-how and the resources to continue DDT manufacture with or without the U.S. market. And if it appears necessary, we would expand our facilities to meet world demand. I move on now to matters perhaps more relevant to the subject assigned to me.

7. Montrose's DDT exports for many years have constituted 70-80% of its total production. In the last ten years these exports

have been largely confined to the 75% DDT Water Dispersible Powder (WDP), Montrose being the principal supplier of this material to the World Health Organization and to the U.S. Agency for International Development for their malaria eradication programs. Their demand from year to year has fluctuated widely, varying from as little as 15 million pounds to about 50 million. With the loss of domestic sales we naturally are exploring ways to replace this with additional overseas business, including direct sales to countries whose own Ministries of Health buy 75% WDP outside the WHO and AID programs.

8. We are also actively pursuing technical DDT sales for agricultural uses abroad. Nevertheless, although the ratio of Montrose DDT sales for health vs agricultural uses is decreasing, the bulk of Montrose's business still is for health purposes. Malaria, of course, is the principal target.

9. WHO's projection of 75% WDP requirements for each of the next ten years--that is, for 1972 thru 1981--adds up to a total of 423,000 metric tons, or about 925 million pounds.[3] It also estimates that maximum consumption will be reached in 1976 when 52,000 tons will be needed, decreasing to 29,000 tons by 1981. The forecast depends on many factors, not least of which, as I've already noted, being the availability of sufficient finances to carry out these health programs.

10. Dr. Whittemore of FAO also made estimates last year of current and projected DDT use for agriculture using two approaches.[4] First, he assumed that total world DDT production was approximately double that of the U.S.A. He then assumed that the amount exported by the U.S. for health use represented 75% of the total global health use. From these figures he was able to estimate that about 61,000 metric tons of DDT on a 100% basis were being used for agriculture outside the U.S.

11. Dr. Whittemore's other approach to guaging world DDT use for agriculture was to estimate the patterns of DDT use on cotton in the various regions of the world, and the number of hectares in each that are planted for cotton. He then assumed that 75% of the DDT used agriculturaly was for cotton, and 25% for other crops. With these assumptions he arrived at a total world consumption for agriculture of approximately 48,000 metric tons. This is to be compared then with the first approach which resulted in an estimate of 61,000 tons, recalling that the higher figure depends on the assumption that the U.S. contributes 50% of world DDT production.

12. Neither estimate can be reconciled with WHO's 1971 annual world DDT production figure of between 200 and 250,000 metric tons. Subtracting WHO's figure of DDT use for public health leaves 150-200,000 metric tons for agricultural use. This is an amount 250 to 400% greater than FAO can account for.

13. Montrose's own survey, which excludes China, leads us to believe that total world DDT production last year was not more than about 70,000 metric tons. Subtracting from this FAO's estimate of about 30,000 tons for health use leaves 40,000 tons for agricultural purposes. This is about 15% short of FAO's 48,000 tons estimate which was based on patterns of DDT use on cotton. Perhaps at least some of the difference can be attributed to--as Dr. Whittemore stated when he proposed his estimate--the somewhat questionably high estimated rates of use on cotton for Latin America. There it had been assumed that 10 kg/ha were being applied in Central America and 5 kg/ha in South America. I now propose to leave this subject with the caution that our own estimates, like those of WHO and FAO, are also only tentative. Obtaining production figures from producers around the world is neither easy nor dependable.

14. Although we have produced DDT for 26 years, we started formulating the 75% WDP only about ten years ago. This was at a time when both WHO and AID were concerned with powders failing in the field, and we decided it was necessary for us to exercise full control over the product by making our own. There were essentially two types of failure. There was plugging of the spray nozzles because the particles were too coarse or agglomerated and then there were powders that did not remain in water suspension long enough to provide an even pattern of DDT particles on the sprayed surfaces. Considerable work was done at the Technical Development Laboratories of the Center for Disease Control (or, as most of us remember it, the Communicable Disease Center) at Savannah, Georgia. Drs. Miles and Pearce were the principal researchers of the causes for these failures and they developed tests which eventually were incorporated into AID and WHO Specifications.[5]

15. Briefly, the evolution of specifications started with the introduction of a minimum package size as far back as 1955 when over-compaction resulted in particle agglomeration and caking; the introduction of the 70°C accelerated storage test in 1961 which has turned out to be a pretty reliable predicter of suspensibility after long-term storage; and the introduction of a suspensibility test in distilled water (this test was introduced when some powders failed when suspended in soft water).

16. In 1966 three more specification changes were instituted. First, the suspensibility requirement after accelerated storage pretreatment was raised from 1.35% to 1.625%. Second, the minimum container size was increased to allow space of not less than two liters per kilogram of powder. For the 34Kilo (or 75 pound) AID box, for example, this is equivalent to an inside volume of

68.1 liters (or 18 gallons). And third, the 12-month shelf-life warranty was introduced. This warranty was believed necessary to insure that powders contained sufficient surfactant to preserve their suspensibility for at least one year. The accelerated storage test already provided assurance that powders in the field would not agglomerate, but it does not predict the stability of the surfactant in storage.[6]

17. When we started 75% WDP production, we initiated a laboratory program to explore singly and in combination all the factors we could identify which might affect the quality of the 75% WDP product. This program continued for about two years during which we conducted several hundred controlled tests, using a small (one inch diameter) air mill and testing every wetting agent, suspending agent and carrier we could find in and outside of the U.S.A.

18. It should be mentioned quickly that you cannot assume good extrapolation from a small laboratory mill, probably because most of these have a higher air-to-feed ratio than the larger production units. As a result we found that some formulations that did well in the laboratory did not perform on a production basis. It is possible too--although not probable--that some test formulations would have performed better in the full size plant. As a practical matter, however, anything that performed poorly in the laboratory was quickly abandoned.

19. We also tested technical DDT in various physical forms and of different ages and p,p'-isomer content. We determined the effects of temperature and humidity; and the effects of compaction, which included building our own laboratory compacter. We concluded that any one of these factors can affect the usability and effectiveness of the 75% WDP when it is applied in the field. This last criterion,

of course, is what it is all about--putting a workable product in the hands of the ultimate user.

20. I think it is generally accepted that only air mills can produce high quality 75% WDP. Air mills, themselves expensive, also require air compressors that are expensive to buy, install, operate and maintain. And air milling requires high energy consumption per unit of finished 75% WDP. A rule of thumb would be that one horse-power will air mill about three Kilos of 75% WDP per hour. Special precautions must be taken that the oil and moisture content of the air to the mill remains very low. It takes very little of either to affect significantly the powder's suspensibility in water, its tolerance to compaction, and its shelf-life stability.

21. I will touch briefly on some of the factors I've mentioned:

22. Climate - It is easier to produce a good quality powder when the weather is cold and dry than when it is warm and humid or rainy. Unfortunately, a plant located in an area where 75% WDP is needed is likely to encounter moist tropical conditions. This does not make the job impossible, but it does mean that tightly closed systems must be maintained. Moreover, it is essential that the charging of raw materials into mixers or bucket elevator hoppers, and the packaging and storage of the powder in its intermediate and final stages be done indoors.

23. DDT Quality - WHO and AID specifications for technical DDT (WHO/SIT/1.R4 and U.S. Fed. Spec. 0-1-514A respectively) require a minimum setting point of 89°C. This is the equivalent of about 73% p,p'-isomer content. Technical DDT of this quality, in my opinion, is marginal in producing a satisfactory 75% WDP, although it probably can be done if you allow plenty of aging of the technical material. Long aging permits maximum crystallization of the

p,p'-isomer from its oily o,p'-isomer matrix, and this increases grindability. I would like to use DDT of at least 92°C setting point and 93 or 94°C is better. This is a p,p'-isomer content range of about 76 to 78%. At Montrose we have a minimum in-house specification of 92°C with the average of the technical DDT we actually grind being above 93°C.

24. Physical Form of Technical DDT - This, and the manner of its crystallization, appear to be factors in the grindability of technical DDT, but it is for the most part an empirical determination. DDT can be crystallized as a flake from a roll mill or a belt; as a powder or granule from water or a solvent; as a chip from a turn-table; or as a crude lump from a shallow open pan. The most I can say, I think, is that for a particular grinding plant one physical form may perform better than another. The suspicion remains for me, nevertheless, that assuming the technical is supplied in a manageable particle size, the physical form is not very important. It may well be that, given the many variabilities present in a plant test run, a physical form is chosen and stuck with simply because all the variables happen to be under control during the test. Conversely, the best DDT you can find may prove unsatisfactory if the test run is not carefully controlled. On this subject I remember when, many years ago, we accidentally contaminated a batch of DDT with trace amounts of a brown dye. From then on the customer insisted that brown DDT ground better, and he was happiest when we had dark material to ship to him.

25. Diluents or Carriers - We have found no effective substitute for the expensive precipitated silica such as PPG's Hi-Sil in the U.S.A. or Degussa's silica produced in West Germany. Nor are all precipitated silicas equally effective for the manufacture of 75% WDP

even though they may appear to test the same in a series of physical and chemical tests.

26. CDC's tests have indicated that up to 3% clay may be added to the fomulation without serious harm.[7] This does reduce the cost, but clay addition--any amount--also reduces quality, and the best 75% WDP, all other factors being equal, is one without any clay.

27. Surfactants - As with the carrier, few wetting agents and suspending agents are suitable. Those that work are expensive. We have found that besides the principal surfactants, the minor addition of a special surfactant appears to extend further the 75% WDP shelf-life.

28. Fineness of Grind - WHO and AID specifications require a minimum of 98% of the material passing through a 200-mesh screen. This simply insures a particle size small enough to avoid plugging the spray nozzle. The test, however, is not a useful measure of the powder's suspensibility in water. Even passing a 325 mesh screen (which means the product is below 44 microns in particle size) would not guarantee good suspensibility. An acceptable 75% WDP has an average particle size of about 2.5 microns or less. This can be determined on the Fisher Sub-Sieve Sizer, which is a useful laboratory tool in assessing the efficienty of the air milling process.

29. Compaction - I have already mentioned the effect of excessive compaction during packaging in reducing suspensibility and storage life. The 2 liters per Kilogram specification provides a container size that can avoid this. It does not guarantee, however, that excessive compaction won't happen. Unless the container is filled to the top--that is, unless you make full use of the space available to you--excessive compaction can and will occur. This is

where close supervision plays an important role. Perhaps this is the point at which to comment on something which those of you with chemical manufacturing experience are no doubt aware of: A sound approach to chemical equipment and process design is to be convinced that, if your imagination conjures up a situation where something bad can happen-whether it is in terms of product quality or production rate or equipment breakdown--then it will happen. Moreover, nobody's imagination is ever good enough. Situations will occur that will exceed your wildest dreams. Besides designing out as many of these pitfalls as you can on a practical basis, close, competent supervision and frequent laboratory checks are the best answers toward minimizing these problems.

30. Storage - I noted earlier that since 1966 AID and WHO require a 12-month suspensibility guarantee by the manufacturer. After one year, a reserve sample made up as a 2.5% suspension in standard hard water must contain a minimum of half of the DDT (1.25%) after 30 minutes of time to settle. These shelf-life tests are conducted by CDC for the AID program and by a commercial laboratory in the U.S.A. for WHO samples. There have been no failures of Montrose-produced 75% WDP for at least five years, although I understand there have been some failures from other sources. Our own laboratory checks, in fact, indicate that the DDT suspensibilities on our reserve samples remain high even after two years and more. I think this offers good assurance that spraying personnel in the field will have no problems with powder quality provided they exercise reasonable precaution in keeping the containers from being excessively exposed to the weather. Most countries, I believe, provide inside storage for the bulk of their 75% WDP supply, distributing containers to points of use in the field only as they are actually ready to spray.

31. Containers - The susceptibility of the 75% WDP to damage and deterioration when exposed to moist, warm air, and the physical demands of long overseas voyages and long land hauls to places of use make it necessary to use an exceptionally rugged container.

32. AID uses a box that holds 75 pounds (34 Kilos) of WDP and which is made up of a corrugated fiberboard liner inside a corrugated fiberboard outer shell.[8] WHO now uses the same box and liner but will also supply material in fibre drums containing 45 Kilos (100 pounds) or 90 Kilos (200 pounds) net WDP with a loose 4 mil polyethylene liner, if the recipient country requests it. Both types of containers with reasonable care against weather have proved to be very satisfactory over long periods of storage.

33. In-process and Product Laboratory Testing - Finally, an essential ingredient in producing consistently high quality 75% WDP is tight quality control. Samples should be taken during the process to be sure that ingredients are being correctly weighed and adequately mixed; that the DDT content stays within tight limits; and that the fineness of grind and suspensibility are being checked as soon as the finished product comes off the line. At Montrose we maintain around-the-clock laboratory personnel to do this and for obvious reasons we keep them independent and apart from the production plant and its people.

34. DDT-Malathion Wettable Powder - More recently, we have been supplying 75% DDT-Malathion Wettable powder for the South Pacific Islands. This powder contains 10 parts DDT to one part malathion, or about 68% DDT and 6.8% malathion. It is our understanding that this mixture is being used in areas where insect resistance to DDT alone is developing. Although there is no evidence of any synergistic action between DDT and malathion, the mixture has been

found effective in achieving very satisfactory insect control. It also has eliminated the necessity of spraying each ingredient separately and therefore affords measurable and substantial savings in labor cost and equipment utilization.

35. I want to touch only very briefly on its problems of manufacture and storage. The process is proprietary with us. Those of you familiar with malathion's physical properties know that obtaining this kind of concentrated mixture with DDT in a free, flowable form, cannot be accomplished by a straightforward mixing of ingredients. If you tried--and we did --you get a mud. But by a substantial investment in time and effort we now have learned how to produce a mixture whose quality approaches that of the straight DDT 75% WDP. Our reserve samples--the initial ones are now about 15 months old--indicated, as we expected, a gradual degradation of the malathion with time, but this appears to level off at about six months to about 6% from the 6.8% concentration in the original mixture.

36. Agricultural DDT Uses - Today, more than a quarter century after its introduction, DDT and other chlorinated hydrocarbons continue to make up between 50 and 75% of the total insecticides used in agriculture in the developing countries.[9] The obvious reasons are that DDT is safe, cheap and still effective against a variety of insect crop pests with cotton consuming 75% of the total DDT used. Other important DDT-use crops are maize, soy beans, citrus, potatoes and ground nuts. Cotton is grown in 20 African, 9 Asian and 13 Latin American countries on an estimated 25 million hectares. In its ten year forecast last year FAO estimated decreases in DDT requirements for Latin America and increases in Asia and Africa, the net change expected to be about a 40% increase, for a total of

69,000 metric tons of DDT used in agriculture by 1980.[4]

37. The manufacture of basic insecticide chemicals, such as DDT, in developing countries requires substantial capital investment and the necessity to import exotic materials of construction and equipment from the more advanced industrial countries and a reasonably close source of raw materials. The number of people required to operate such plants usually is small and highly skilled.

38. In contrast, formulating plants are simple to build, require relatively common materials of construction--usually steel--and require the bulk of the personnel to perform relatively simple kinds of tasks. This is not to minimize the necessity for proper training, particularly in safety, since plants of this nature also require the formulation of some fairly toxic to highly toxic materials. Along with training, of course, is the need for setting up machinery for the monitoring of the workers, installing adequate ventilation and maintaining good housekeeping and proper clothing rules. But such plants, because they can often utilize local materials and an abundance of labor, can be attractive additions to a developing country's economy.

39. In the late forties and in the fifties well over 90% of the agricultural DDT formulations were dusts. There was a gradual switch in the late fifties and in the sixties to water-dispersible DDT powders and emulsifiable oil concentrates, particularly as environmental concern with drift increased, so that today dusts, particularly in the U.S., are used very sparingly. For cotton, emulsifiable oil concentrates are far and away the most used DDT formulation. The use of dusts, nevertheless, has a legitimate role in certain situations. For example, for application to crops with dense foliage the billowing action of a fine dust obtains better penetration of all surfaces than do wet sprays.

40. If we were to confine ourselves here only to the problems of formulating DDT into oil and emulsifiable concentrates there is little to say that is not already well known. Plant design can be very simple, with little more than solvent, mixing and storage tanks. Where there is a plentiful labor supply much can be done manually that otherwise might be done with expensive equipment in countries employing scarce and expensive labor.

41. But an important prerequisite to establishing a formulating plant in a developing country is to determine which indigenous raw materials--such as solvents and local clays--can be successfully used. This requires careful advance testing by chemists and agronomists of a variety of physical, chemical and sociological properties, each important in the successful preparation, use and effectiveness of the final formulation. Although there are rules of thumb that sometimes can be used, expert formulators would be the first to admit that their pursuit is still mainly empirical. For a particular area of use, each formulation should be prepared and successfully tested in the laboratory with local materials before proceeding to a production basis. Trace amounts, for example, could produce undesirable phytotoxicity in a local clay; or could reduce needed emulsifiability of a concentrate prepared with a local solvent. In overall charge, then, should be a good administrator who is himself (or has people under his command who are) competent in a range of technical areas such as analytical and formulation chemistry; entomology; and plant physiology and pathology.

42. Some of the physical and chemical properties that would play a part in successful formulating are specific gravity, solubility of the pesticide in the solvent available; stability of the pesticide in the local environment and specific storage conditions;

compatibility among the component ingredients; flowability (if a powder); absorptivity of carriers to be used; particle size; distilling range, flash point, viscosity and aromatics content of solvents; phytotoxicity; caking properties; and at least as many more as already noted.

R E F E R E N C E S

1. Sweeney, Edmund M., "Excerpts from Hearing Examiner's Recommended Findings, Conclusions, and Orders," Environmental Protection Agency. Washington, D.C. Consolidated DDT Hearing, April 25, 1972.

2. Ruckelshaus, William D., Opinion of the Administrator (Before the Environmental Protection Agency in Re: Consolidated DDT Hearings) June 2, 1972.

3. Rafatjah, H.A. and Stiles, A.R., "Summary Review of Problems Confronting DDT for Use in Malaria Control Programmes," Meeting of Pesticides Working Group, WHO Geneva, 10-11 February 1972.

4. Whittemore, F. W., "Future DDT requirements for Crop Prctection in the Developing Countries," Meeting of Pesticides Working Group, WHO, Geneva, 10-11 February 1972.

5. PHS/NCDC Specification -1-102a, January 15, 1970; WHO Specification WHO/SIF/26.R1, 23 April, 1971.

6. Miles, J. W., Goette, M. B., Pearce, G. W., "A New Nigh-Temperature Test for Predicting the Storage Stability of DDT Water-Dispersible Powders," Bulletin World Health Organization, 196, 27, 307-309.

7. Miles, J. W. and Pearce, G. W., "Factors Influencing Storage Stability of DDT Powders," Document VCB/ICC/68.2, WHO, June 1968.

8. Specifications Covering Corrugated Boxes for Shipping 75% DDT, PHS/NCDC Specification-BX-100a, 6 September, 1967.

9. Pesticides in the Modern World, A symposium of FAO and other United Nations Organizations, 1972.

12.8.74