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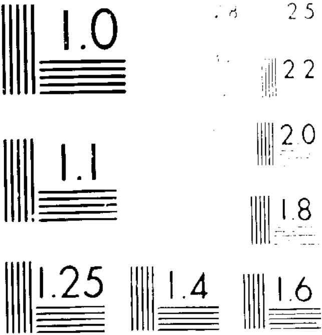
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DP/ID/SER.A/422
23 February 1983
English

BIOSCIENCE AND ENGINEERING

DP/IND/80/003

INDIA

Technical Report*

Prepared for the Government of India by the
United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of N.F. Cardarelli, Consultant on Controlled Release Technology

United Nations Industrial Development Organization
Vienna

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ABSTRACT

The Controlled Release aspect of the subject DP/IND/80/003 was reviewed in depth. Assessment o' the quality of work and the credentials of the personnel were made. The development of "controlled release temephos" monolithic dispenser based upon natural rubber latex was successful as evidenced by the long term emission (9 months) obtained. The initial small scale field trial was underway during the review period. Design parameters were sound. Future plans regarding expanded field testing and interfacing with public health personnel have been laid.

The development of Controlled Release carbofuran for rice insect control is the second major project goal. The complexity of the project has been appropriately handled by the personnel involved. Two approaches have been undertaken-addition of carbofuran as the technical powder or formulated granule to a natural rubber latex vehicle and the coating of this on rice plant seedling roots; and the macroencapsulation of this systemic insecticide in crosslinked starch for use both as a root dip and an area treatment. A demonstration of the feasibility of a root dip was observed. The controlled release starch dispenser was workable, but release longevity was only 19 or 20 days. However, reformulation using oil and secondary polymer additives was underway and the process

examined should reasonably modulate release rate and allow achievement of the 60 to 90 day release life objective. To date the peroxide cross-link has been investigated. Other somewhat more expensive techniques may be necessary if formulation additives fail to properly moderate release. Carbofuran/starch dispensing granules suspended in natural rubber latex are also under evaluation as a controlled release root dip.

The three basic groups involved latex-temephos compounding, starch-carbofuran compounding and entomology, interface with each other and various support services. A spirit of co-operation and enthusiasm pervades the professional members of each project segment. However, lines of authority and communication could be improved. There is a need for a single Project Director whose sole function is to coordinate and direct all aspects of the program.

The objectives sought are sharply focussed and reasonably attainable. Program milestones have not been well-defined to date and consultant visitations unreasonably detained. Resources, especially laboratory processing equipment, are lacking in some areas, and have somewhat retarded progress to date. Future progress, however, will be seriously hampered unless mixing equipment is promptly obtained.

The goal of developing the National Chemical Laboratory as a center of excellence in Controlled Release will not be attained in the foreseeable future without expansion of the basic program into other critical areas involving insecticides, herbicides and pheromones in not only monolithic dispersions and macrocapsules; but also in microcapsules; and examination of other natural and inexpensive polymers such as the cellulosics. Training of personnel in the areas of ecological evaluations, culturing of pest insects, especially those affecting rice production; residue study techniques based on more sophisticated instrumental analysis emphasizing the use of radioisotopes are needed. Greater exposure to Controlled Release Technology through in-house visitation and seminars or lectures by experts in the areas is needed as well as attendance at appropriate scientific symposia and visitation by Indian professionals to Controlled Release Centers in the United States, Belgium, Austria and elsewhere are indicated. An agronomist ought to be assigned full time to the program.

The author delivered six lectures on controlled release technology, provided advice to the working groups, discussed the project in detail with each group leader and his professional colleagues, assisted in the development of future working plans, examined project laboratory facilities and support facilities and consulted at length with key personnel. A potential manufacturer in Bombay was visited by the author to assess the potential for commercialization. A plan of action was devised in meetings with the Laboratory Director and senior scientific personnel. Local public health authorities were contacted to determine exact needs as regards the temephos dispensers. Also the author journeyed to New Delhi to examine the possibility of the Indian Agricultural Research Institute handling large scale rice paddy testing of Controlled Release Carbofuran.

INTRODUCTION

The formulation of pesticides in controlled release dispensers is an emerging technology well suited to the needs of developing nations. The basic advantages are (1) Decreased use of the quantity of toxic agent necessary for target pest control (2) extension of the time frame between repeat pesticides application (3) General reduction in environmental contamination and (4) Dramatic increase in safety for the applicator. The extension of the application interval and the need for significently less chemical agent results in both increased agricultural yield and decreased expenditure at the producer level. By the use of the controlled release methodology in Public Health application-emphasizing insect vector control; the health of the agricultural producer is enhanced thus increasing his productivity. The overall result is increased food supply so critically needed in many areas of the 3rd world. A rice yield increase of 2 to 4 metric tons per hectare at an expenditure at less than 25% present pesticide application cost is achievable.

The use of natural polymers as opposed to the much more expensive synthetic materials is indicated. Synthetics in general must be imported and almost all such polymers are derived from petroleum stocks or natural gas which are non-renewable natural resources. In contrast the natural polymers are renewable plant products and easily available in most developing nations. Such materials are natural rubber and vegetative by products such as starch lignin and other cellulosics.

The DP/IND/80/003 subject programe was requested based upon the proven need, some degree of experience with controlled release, obvious advantages and objects keyed to enhancing agricultural output and public health. The program was formally initiated in September 1981 with a predicted completion in 1986.

RECOMMENDATIONS

A. Major

1. Decrease the completion date for the temephos/ natural rubber product to June 1985. Present progress indicates that reformulation studies should be completed in 3 months, field trials within 9 months. Dispenser design within 9 months. Ecological evaluation within 15 months large scale field tests within 24 months and residue studies within 30 months.
2. Decrease the completion date for the carbofuran aspect to December 1985. Formulation studies should be reasonably completed within 4 months. Field trials within 12 months, Ecological evolution

within 24 months and large scale testing within 30 months. Residue studies ought to be complete within 36 months.

Recommendation 1 and 2 are based upon the adherence to the following correlary recommendations.

3. Reformulate Natural Rubber Latex with increased temephos content using calcium carbonate or other inexpensive fine powder fillers as absorbants and/or porosigens

4. Enlarge the mosquito rearing capability to a production rate of 5000 larva per week.

5. Culture and mass rear the following rice insects: the stem borer, Typoriza incertulus; leaf hopper Nephotettix virescens and the plant hopper, Nilaparvata lugens.

6. Provide training for the Entomology group in order to meet item 4 above through visitation to laboratories presently culturing the noted pests.

7. Provide the following laboratory processing equipment to the formulation groups.

   i) Pulverization unit (1)

   ii) Emulsification unit (2)

   iii) Suitable high speed laboratory mixers (2)

   iv) Ancillary glassware including 10 liter reactors and accessories (2).

   v) Coating apparatus (for rice seeds)

   vi) Comminution unit

   vii) Casting trays

8. Add an agronomist and an aquatic ecologist to the project team.

9. Separate insect rearing and culturing areas from Bioassay areas to minimize pesticide contamination. A separate insectory is indicated.

10. Provide the following equipment to the Entomology group.

    i) Insect rearing cages

    ii) Temperature and humidity controlled environmental chambers (or incumbators).

    iii) Humidifiers for rearing rooms.

    iv) Thermostatic heaters and air conditioners for the rearing rooms.

    v) Accessary materials such as wire screening and the like to allow the construction of mosquito larvae and insect retainers.

11. Provide training in radioisotope techniques to one individual from the compounding group and one from the entomological group. A six weeks basic course is adequate.

12. Provide radiolabelled temephos and carbofuran using single site and multiple site labels for the former.

13. Provide sampling tools for measuring insect density in the natural environment.

14. Step up the time table for the visitation of foreign Experts in Controlled Release, the following being recommended:

    i) Dr. Baruch Shasha - March 1983 (Expert on CR starch xanthate)

    ii) Dr. Robert Peterson - April 1983 (Expert on Rubber latex compounding for CR)

    iii) Dr. Danny Lewis - May 1983 (Expert on CR formulations)

15. Monthly reports from the three working groups ought to be submitted to the project directors.

16. A need exists for some additional training for personnel doing formulation work. In this regard it is recommended that a rubber latex compounder be sent to NCL for 2 or 3 weeks to provide instruction.

B. Minor Recommendation (based upon expansion of the present program in order to achieve the goal of developing NCL as a Center of Excellence in Tropical Controlled Release Technology)

1. Attendance of Select Personnel at the 1983 and 1984 Controlled Release Symposia held by the Controlled Release Society. At least 4 senior scientists should attend.

2. Visitation of senior project personnel to controlled release laboratories and pheromone development laboratories in the United States (Southern Research Institute, Stolle R&D Corporation, U.S. Dept. of Agriculture Lab at Kerrville Texas, Gainesville

Florida and Beltsville Maryland; Hercon Corporation, Albany International, Zoecon Corporation, Unique Technologies Inc. and field sites where control programs are in progress); Australia (Consolidated Fertilizers Ltd., Melborne), Belgium (Gent University) and Austria (FAO, Vienna, IAEA, Seibersdorf).

3. Enlargement of the library collection to include pertinent texts and proceedings regarding controlled release technology and ancillary material on pesticides, toxicology, agronomy and ecology.
4. Purchase of the following items.
   i) Laboratory rubber extruder.
   ii) Laboratory plastic extruder with ancillary wind-up and cooling equipment.
   iii) Pelletizer
5. Proceed with the projected Dursban project.
6. Proceed with the discussed water Hyacinth control project. This aquatic weed is not suitable for Biomass conversion to alcohol etc. due to its high processing cost- as borne out in numerous study projects in the United states, and elsewhere.
7. Institute studies involving the following materials in natural polymers.
   i) Tributyl tin fluoride as a mosquito control agent using monolithic dispensers.

ii) Mating and aggregation pheromones in static trapping systems and contact toxicant systems.

iii) Low alkyl esters of 2,4-D and dichlobenil herbicides in natural rubber, lignin and other cellulosics- such as hydroxymethyl cellulose.

8. Develop microencapsulation techniques for synthetic and natural pesticides based upon coascervation and interfacial polymerization technology.

REPORT ON PROGRESS

1. Controlled Release Mosquito Larvicide

Mr. D. Ragunath has successfully developed a long lasting mosquito larvicide based upon the incorporation at temephos (Abate^{TM}) in natural rubber latex. Nine months release was noted under laboratory conditions. However, this experiment must be replicated to assure repeatability. Dispenser design geometry is in progress. Plans have been made for the study of dispenser placement parameters under varying field conditions. At the suggestion of the author, Dr. R.N. Sharma, Head of Entomology has designed a field trial based upon the placement of contained mosquito 3rd instar larva at varying distances from a dispenser. Treatment dosage was based upon the laboratory studies of Mr. Ragunath and just completed out-door aquaria studied devised by Dr. Sharma. This test is properly designed to determine water transport characteristics as measured analytically and concurrently by bioassay. The results will assist in the dtermination of a dispenser placement pattern for static water bodies. The author observed the tests during its progress. Also a flowing water cascade system is under construction.

The personnel involved will be co-operating with local mosquito control teams as they scale up to field evaluations.

2. Controlled Release Carbofuran for Rice Root Dip Application.

At the suggestion of the author, Mr. D. Raghunath set-up and completed a novel experiment wherein wheat seedlings were root dipped in a natural rubber latex/ carbofuran dispersion. He and his assistant had first determined the proper latex concentration that allowed bundle dipping without interroot adhesion by first dipping at various concentrations. Microscopical observation showed proper root adhesion and covering. Wheat seedlings were used in lieu of the availability of rice plants which were out of season. The Entomology group used staining techniques to enhance observation. The author viewed the subject dip treatment and confirmed through microscopic observation that the goals were met. The seedlings were than observed in water and transplanted in soil to determine whether proper water and nutrient intake through the thin latex/carbofuran coating occurs. Wheat growth continued often planting. After 7 days plants were uprooted and the latex film was still affixed to the roots. A study using radio labelled phosphate ion is planned to examin the effect of a latex coating on water intake.

3. Controlled Release Carbofuran in a Xanthated Starch Macrocapsule

Mr. N. Rajagopalan directed the study resulting in the incorporation and slow emission of carbofuran insecticide from crosslinked starch. A release rate of 18 or 19 days was noted. Thus feasibility is assumed, although the longevity must be extended to 60 to 90 days for practical viability. Reformulation to achieve this extended release duration was in progress. By the incorporation of a hydrophobic additive, Mr. Rajagopalan rightly believes that the resulting decrease in water ingression will retard loss rate. Both an available natural oil, suggested by the author, and a secondary polymer, polystyrene were selected at various loadings for this study. The chemical preparation and crosslinking of the starch was observed by the author and noted as properly and expertly performed. The resulting granule is presently in loss rate evaluation tests. Both release retardants significently slowed loss rate and after 10 days examination of data, longevity in excess of 30 days is predictable. Lack of proper comminution and sizing equipment hampers progress. Similarly the need for appropriate mixers reduces quantitative output and increases reaction time so that only one or two formulations in low quantity can be prepared daily.

This segment of the project is keyed to developing a granule that can be hand broadcasted in rice paddies and will provide 60 to 90 day insect control.

4. Controlled Release Carbofuran in Xanthated Starch as a Root Dip treatment.

It was recognized that carbofuran, a systemic insecticide absorbed by the rice root structure would provide better insect control if applied in the root zone of the plant as opposed to the broadcasting of non-controlled release carbofuran through the entire water body as is the conventional practice.

By combining the carbofuran/starch program with Mr. Ragunath's expertise in latex compounding, Mr. Rajagopalan suggested dispensing the controlled release carbofuran/starch dispensers as granules in rubber latex- and performing root dip evaluation on wheat seedlings substituted for rice. By adhering the carbofuran/starch directly on the roots-which is confirmed by this author, through microscopical observation, as is indeed the case-one can treat only the roots, where the agent is needed, and not the entire water course where most of the agent is wasted. Experiments are under way to determine the efficacy of this new application technique.

5. OTHER PROJECTS

Some attention has been devoted to the use [illegible] urea polyamide and polyvinyl alcohol as the encapsulating matrix for both carbofuran and fenitrothion. This is a minor effort and properly so, since the subject polymers are considerably more expensive than starch and natural rubber. However, this effort will provide an extension of in house training and capability in controlled release technology.

A controlled release system for NEEM seed extract, an antifeedent, is being developed.

OBSERVATIONS OF THE EXPERT

1. **Schedule**

The project has appropriate goals and the program appears to be well focused on their achievement. Although the overall program is well devised, milestones are not prescribed and there is no comprehensive schedule. Steps have been taken in consultation with Dr. L.K. Doraiswamy, Laboratory Director, and Dr. R.B. Mitra, Project Director to develop a detailed schedule.

The optimal temephos/Natural Rubber compound should be reformulated for bioassay replication and to increase the temephos loading, thus reducing dispenser size. Currently field trial experimental designs should be devised and initiated keyed to determining dispenser distribution in the varied water environments. An interface with Mosquito control authorities is essential at this point. Field trials are necessary in order to develop an appropriate methodology; dosage, dispenser design, placement patterns, etc., for use in field tests. The simple ditch bioassay devised and extended from 1 to 3 test sites during the authors stay; and the cascade type flowing water system suggested by the author and now under construction represent the initial approach to developing the application methodology.

Field trials involving collection of ecological and residual data in support of registration ought to be completed within 30 months.

An interface with the chemical engineering group has been established and their input will assist in program acceleration.

Similarly the carbofuran/starch and carbofuran/rubber latex rice root dip studies lack a firm schedule. This program is, in past, retarded due to lack of hard data concerning rice culture. This deficiency can be corrected by adding a knowledgeable agronomist to the carbofuran/latex and carbofuran/starch programs.

Personnel

Dr. R.B. Mitra the program director has installed a spirit of enthusiasm and motivation in the professional and sub-professional personnel involved in this project. This is evidenced by their willingness to work late hours and on the week ends during the author's visit so that maximum knowledge could be imparted. The key personnel involved, Dr. Sharma, Mr. Raghunath and Mr. Rajagopalan have shown by their actions, high motivation, and by their questions a desire not only to excell in the present undertakings but to broaden their own involvement in Controlled Release Technology by expansion of the present studies and contemplation of other areas of investigation such as with pheromones and neem seed insecticidal extracts.

Similarly pointed questions and the desire for expert advice by others, such as Mr. Amarnath on controlled release compounding, Mr. Harish Narian, Mr. Shukla and various members of the Entomology section indicate to this author that these individuals are well motivated.

It was noted, however, that in spite of the aforesaid obvious dedication and undoubted capability that various researchers involved lacked a feeling of confidence in their own ability to excell. It is believed that this is due to their relative isolation from contact with individuals, such as expert consultants and interfacing at meetings and symposia with controlled release scientists, lack of appropriate equipment and lack of pertinent literature.

National Chemical Laboratory groups, outside those directly involved in the program were contacted by the author as to their ability to offer needed support services. These include Dr. Sivaraman of Biochemistry whose personnel have the facilities and ability to assist in radiotracer techniques for metabolism, ecology and residue studies; Dr. R.A. Mashalkar and Dr. V.M. Nadkarni of the Polymer Science and Engineering group who will likely have the pilot plant responsibility and others involved in analysis, physical chemistry and processing.

The author provided guidance in field trial design, formulation changes of starch matrices, and the rice root dip concept.

Experts Input

The author by his presence alone was able to indicate to the various project members that they wereperforming admiringly well-even though isolated from appropriate contact with colleagues in CR technology and often lacking in equipment. All appeared eager to consult with and ask advice from the author.

Help was given to the compounding group by suggesting formulation modifications to provide increased longevity. Also a recipe for NEEM seed formulation to enhance leaf adhesion in tobacco was provided.

Long meetings were held with Dr. Mitra concerning the overall program and the section leaders as to the details of compounding, test design and the like. Assistance was rendered as concerns various minor details. Planning meetings and discussions were held as needed- see appendix 1,2 and 3, for those of major importance.

In order to enahnce knowledge concerning controlled release the author provided five lectures of about 45 minutes, 1 per day, plus a question period. The lectures were well attended by not only the project members but others at NCL as well.

Lectures provided were:

1. Principles of controlled release and historical development of elastomeric monoliths (antifouling and molluscicides).
2. Elastomeric monoliths: Incecticides, herbicides and the chronicity principle.
3. Laminated structures, pheromones, carrier principle.
4. Thermoplastic monoliths: Dispenser design, laminated systems, porosigen principle.
5. Microencapsulation, Semi-encapsulation, Agricultural needs.

In order to render maximum assistance, the author continued his consulting activities on both week-ends involved and extended his stay for 3 extra days at no additional expense to the contracting agency.

A visit to Excel India Ltd. in Bombay was made in order to discuss commercialization potential. The author met with Mr. S.S. Kaimal and others in this regard.

Also Public Health Officials were contacted in order to get their views on the Temephos dispenser. Where should it be used? Placement Scheme, and the like. Discussions were with Mr. Gopal Sa.vadkar, Pest Inspector for Pune. Under his direction we inspected various problem areas, including wells, ponds, sm[illegible] es, and the river margin. The interaction of [illegible] acinth Infestation with mosquito breeding was obvious. Where the Hyacinth mats exist not only are environmental conditions favourable for the mosquito, but larviciding is impossible.

Examination of mosquito breeding sites is necessary in order to design the dispenser units to meet the environmental parameters. Dispenser will not be useful in all areas, although it is reasonable to believe that public wells, ponds, and small water holding areas - pondlets, old tires, metal containers etc. could be appropriately treated with temephos dispensers. In areas where the Gambusia fish has been introduced as a biological control, the merit of adding a chemical agent would have to be examined carefully. Whether river margins are susceptable to larvacidal treatment is a subject for investigation.

In the area, treatment is by spraying on an 8 day cycle during mosquito season (which is 8 months of the year). Since the temephos dispensers provide, at least in the laboratory, 36 weeks release, they may be cost beneficial for use in the local area.

The Indian Agricultural Research Institute in New Delhi was visited and the potential use of IARI facilities to handle extended rice paddy tests were discussed with Dr. S.K. Mukherjee and others.

Various National Chemical Laboratory facilities were toured in order to assess services available from support groups as well as those directly involved in the program. This can be summarized as follows:

1. Library - excellent journal collection in general, although Entomology offerings were somewhat lacking. Some lack of texts and proceedings on controlled release technology.
2. Glass Blowing - Excellent
3. Workshop - Excellent facilities, but perhaps a little slow in fulfilling researchers requests.
4. Analytical instrumentation and personnel - Very good. Results are impressive and personnel capable and well trained.
5. Physical Testing - Excellent equipment, some units outdated but adequate for needs.
6. Rubber processing - Adequate equipment but lacking in small press capacity and extrusion.
7. Radiotracer facilities - Excellent. New and very useful equipment for the CR program.
8. Entomology labs. - Excellent though crowded. Personnel are capable and well motivated.
9. Rubber compounding lab. - Adequate except lacking in necessary mixing and comminution equipment. Could use a top loading balance.

Appendix I

Controlled Release Technology

Development of mosquito larvicide based on Monolithic Matrix - Natural Rubber Latex.

PROGRAM PLANNING MEETING

Group

1. Mr. D. Raghunath
2. Mr. N. Amarnath

Prof. N.F. Cardar lli, (UNDP Expert) our authority on the Controlled Release Systems, based on Monolithic matrices - Elastomers and Plastics, was explained in detail the successful development of the C.R. formulation based on Natural Rubber latex and Abate - (Temephos) as a mosquito larvicide. The various formulations, the technology and the Bioassay conducted on the successful formulation (longevity 36 weeks) was described.

After familiarising with the details, a meeting was arranged on 29th November 1982 in the Board Room where the following persons took part in the discussions.

1) Mr. N.F. Cardarelli
2) Dr. R.B. Mitra
3) Mr. D. Raghunath
4) Mr. N. Amarnath
5) Dr. R.N. Sharma
6) Mr. I.V. Bhaldar.

Appendix I

Mr. Cardarelli expressed that since the Natural Rubber Latex based Mosquito larvicide has been worked out successfully with enough data, a technical paper should be submitted for presenting at the Controlled Release Symposium to be held sometime in July 1983 in USA; at that time the person/persons deputed by NCL could visit various institutions in the States where similar type of work is being carried out.

Mr. Cardarelli suggested that since a lot of work has been done on Natural Rubber Latex based formulations, further work could be carried out on the development of formulations for Dursban, (for soil application against Nematodes) and Furadan (against Stem borers, Rice insects).

Mr. Cardarelli indicated that it would be appropriate to study the effect of fillers, such as carbon black, calcium carbonate, Kaolinite on the longevity of the product by loading various proportions, keeping the active agent constant and also study the solubility of Temephos in Natural Rubber latex and the use of Porosigens. Further he suggested the development of dispenser design, the study of the transport of the toxicant in water with reference to its placement in pond or ditch. Mr.Cardarelli suggested the residue studies of the toxicant by Radio isotopes; it was also indicated to study the suitability

Appendix I

of the Rubber latex (3% to 5% Rubber) in root dip formulations for use in rice plants; labelled isotopes should be used to determine the suitable concentration of rubber in the latex form; i.e.does the latex root film permit proper plant intake of water and nutrients.

Composed by:

Mr. D.Raghunath

Appendix 2

Product Development Plan devised by Dr. R.N. Sharma in consultation with Professor Nate Cardarelli.

Development Plan

I Mosquito Larvicide

1. Preliminary assessment of new formulations in pure water system (3 L jars/bigger drums).

   a) Determination of actual longevity/persistence (in terms of 100% kills of mosquito larvae) of formulations of different strengths/placements.

   b) Determination of Release Rates/Effective concentrations for short term (1-2 months), extrapolation/projection of this data for extended time.

   c) Comparison of (a) and (b).

2. Large tank/Aquaria trials

   With inorganic (sand, silt, gravel) and organic (plants, fishes) Biomass.

   a) Determination of magnification of dose required in presence of biomass.

   b) Determination of most efficient placement levels-both vertically and horizontally.

   c) Determination of validity of surface area vis a vis Volume: Dose relationship.

   d) Effect of non-target organisms:

      Aquatic plants; fishes; mice crustacea, water insect, toxicity, enzyme inhibition etc. (Technical toxicant Vs CR formulation)

   e) Demonstration of toxicant dispersal in the total system.

Appendix 2

I Measurement of larval mortality in

i) Water samples
ii) Suspended cages
iii) Free larvae

II Assessment of toxicant residues in

i) Plant samples
ii) Fish
iii) Soil
iv) Scrapings off glass walls

3. Trench Trials

a) Measurement of transport of toxicant in system simulating natural conditions i.e. in presence of plants, fish, etc.

b) Determination of most efficient dispenser placement level.

c) Determination of dispenser spacing using data from (a) above.

d) Determination of dose magnification required, if any, compared to (2).

4. Actual field trial:

for a) Septic tank
b) Pond
c) Ditch
d) Well

Using data from 1,2 and 3 and final enunciation of application strategy for stagnant waters.

5. Determination of parameters as in 4 for

Flowing water systems.

6. Evolution/standardisation of methods/procedures for above.

Appendix 2

II Rice Paddy Crop Protection

Toxicant: (a) Carbofuran (b) Dursban

1. Bioefficacy of the controlled release formulation vs Furadan 3G in root application

   a) Plant uptake of toxicant — Bioassay
metabolites — Radio isotopes

2. Bioefficacy of CRF Vs Furadan 3G in seedling/crop plants:

   a) Plant uptake of (i) toxicant (ii) Nutrients
   b) Effective soil/water concentration of toxicant required
   c) Determination of (b) for effective prophylaxis for maximum period.
   d) Application strategy.

3. Overall enunciations of most efficient

   Parameter: Yield

   Evolution/standardisation of methods/procedures for above.

III Nematodes

Toxicant: Carbofuran/Temik

1. Root Knot Nematodes on

   a) Wheat
   b) Vegetable crop
   c) Tobacco

   Assessment of CRF Vs Furadan 3G as soil applicants (laboratory, field trials).

2. Comparison of number applications of furadan versus one application of CRF: Cost benefit analysis.

   (Application Costs); (Amt. insecticide actually required).

3. Evolution of efficient evaluation systems: yield, other.

   This requires the laboratory culture of quantities of Nematodes and the development of handling techniques.

Composed by:

R.N. Sharma

Appendix 2

Equipment - Consolidated list

1. Environmental chambers (different sizes): 3 Nos.
   Illumination, Temp. humidity controls

2. Glass houses: 2 Nos. (Different sizes)

3. Environmental regulators

   1-1/2 tons (a) Air conditioners - 6 Nos.
   (b) Heaters: 12 Nos
   (c) Dehumidifiers: 4 Nos.

4. B.O.D. Incubators: 3 Nos.

5. Aquaria (glass/perspex tanks) diff. sizes: 2 dozens

6. Diluting/dispensing systems
   a) Microprocessor pipettes/pumps (Hamilton)
   b) Macrosystems (Waters Associates)

7. Disposable dispensing pipettes: Pushbutton/digital

8. Water flow/rate meters (Kruz, USAO.

9. Air flow/velocity meters (Kruz, USA) including separate pocket anemometers (Kruz, USA)

9a. Portable Digital pH meter.

10. Electronic balances (Metler/Sartorius)

   a) Single pan, micro
   b) Top loaders, 0.01 mg. Sensitivity with print out
   c) Animal weighing ones

11. Electronic/digital (Li-Cor, USA)
   a) Area Meter (b) Light meter (air and water sensors)

12. Moisture balance (micro weights)

13. Seinhoast Elutriator (Netherlands)

14. Insect Barriers oscillators/trappers (Burkard) USA/UK

15. Isolation plant propogator (Burkard) USA/UK

Appendix 2

16. Thermohygrographs: 6 Nos.

    Hygrometers: 6 Nos.

17. Electreoantennogram assembly (Tetronix)

18. Double Beam Scanning Spectrophotometer with automatic recorder, temp. controller etc. (Shimadzu)

19. Colony counters (Teansistorised) (Burkard) USA/U.K.

20. a) Refrigerators : 2 Nos.

    b) Deep Freeze : 1 No.

21. Germicidal/U.V. lamps

22. Photographic camera with attachment lenses for (a) Micro (b) Near (c) Far (d) Motion (e) Distance photography (RICOH, Japan or Robot, USA).

23. Soil sampling tools (U.K.)

    a) Oscilloscopes : 2 Nos.

    b) Amplifiers etc. : 6 Nos.

    c) Sound/Photo recording system.

24. Hardware for cages, rocks, sieves, canopies, traps, inoculation chambers etc.

Appendix 3

WORK PLAN : BY R. Rajagopalan

A. Controlled Release Carbofuran systems encapsulated in starch-xanthide matrix

1. Product for Soil Application in Rice Cultivation

AIM and SCOPE: In rice cultivation, conventionally, carbofuran in the form of 3% commercial formulation (3C) is applied to soil two to three times at intervals of one month each to protect the rice plants mainly from the stem borer. The aim of the project is to develop controlled release formulations which will last at least for two months so that a simple application of much less active ingredient will suffice for the whole season.

Studies in developing suitable controlled release formulation of carbofuran in starch xanthide matrix has resulted in a product which releases continuously over a period of about 20 days only.

With a view to reduce the release rate further so as to last for 60 days, the following aspects will be studies:

i) A mixing of hydrophobic materials like vegetable oil, polyestyrene etc. with carbofuran prior to encapsulation so as to render it less hydrophilic. Preliminary work on these lines shows promise and this will be investigated in detail.

ii) Coating the encapsulated granules with hydropholic polymers like polyestyrene, natural and synthetic elastomers by treating with their dispersions (latex) [redacted] in water, and then drying the granules.

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iii) Post-canning (or cross-linking) of the encapsulated granules with other cross-linking agents for starch like (di) aldehydes, epichlorohydrin, urea-fomaldehyde resin, boric acid etc.

2. Root-Dip Formulation

AIM and SCOPE: A dispersion of controlled release carbofuran (in starch xanthide matrix) in aquous solutions of film forming polymers such as starch and cascin or in rubber latex will be developed. Roots of the rice plants will be dipped in this dispersion and allowed to air dry before transplantation. Thus a protective film incorporating the encapsulated carbofuran will be formed around the roots of the plant which is the actual site of the pesticide uptake. This can considerably reduce the quantity of pesticide application as compared to the conventional soil application and can also give protection to the plant for the whole season.

At present, the conventional root dip procedure involves dipping the roots of the rice plant in a slury of commercial (3%) carbofuran granules. This is supposed to give protection to the plant for about 20 days.

A detailed study involving preparation of suitable dispersions and their application to rice plants will be taken up by February 1983 i.e. in the next rice season. This will also include the study of the transport of water across the polymer film around the roots by radiotracer technique using labelled sodium phosphate.

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3. FIELD TRIALS: Initially tests will be carried out in small laboratory plots in which rice plants will be grown and rice stem barers will be introduced to study the efficacy of both the soil as well as root dip CR products. Field trials will be taken up after successful completion of the above studies.

B. FUTURE WORK

i) Investigations regarding (a) the rate of uptake of carbofuran by the plants, (b) their residence in the plants, (c) the effection concentration level in the plants required and (d) their assimilation, metabolisation, degradation etc. in the plant are necessary, preferably by tracer techniques using labelled carbofuran.

ii) Further experiments with microencapsulation of fenitrothion in polyurea and polyamide matrices will be continued to achieve a satisfactory formulation.

iii) Dursban and other liquid pesticides will be encapsulated in starch xanthate matrix to work out formulations with low mammalian toxicity as well as slow release characteristics.

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