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CHINA

Technical report: Mission to the Shenyang Institute of Chemical Industry Pesticide Division*

Prepared for the Government of
People's Republic of China by the
United Nations Industrial Development Organization

Based on the work of Mr. K. J. Brent
Consultant on Plant Pathology

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

Visit to the Shenyang Research Institute of Chemical Industry by Dr. K.J. Brent, July 1985: Final Report

Contents:

Summary

1. The author visited China for the period 27 June - 11 July, 1985. The aim was to review progress and advise on the further development of the pesticide research programme at the Shenyang Research Institute of Chemical Industry (SRICI), with special reference to fungicide research.

2. Nine days were spent at SRICI. Visits were made to all relevant departments of the Institute, and to the new site at De Sheng Yin where the toxicology building is nearing completion and a new bioassay complex is to be sited.

3. Two lectures were given on 'Recent Trends in Plant Disease Control' and 'Discovery and Evaluation of Fungicides'. The author led group discussions on these topics, and on future activities at SRICI. Advice was given on management of the pesticide research programme, bioassay methods for fungicides, purchase of equipment and lay-out of future buildings and glasshouses.

4. Information was obtained and passed on to two further experts, to aid preparation for their visits in October 1985.

Recommendations

1. Plans for the new bioassay building and for purchase of controlled environment facilities and other equipment, should be modified and further developed by SRICI in the light of advice given in this report and during the visit.

2. Four six-month training fellowships in the UK should be arranged for 1986 and 1987, and the candidates interviewed by the author are considered suitable.

3. A programme of in vivo tests for protectant and systematic fungicidal activity against a range of plant diseases should be set up as soon as possible. This will depend on the completion of the new bioassay facility at the De Sheng Yin site. A field-testing programme, involving experiments at this site and elsewhere in China, also should be developed.

4. Throughput of candidate compounds for pesticide screening and evaluation should be increased, and plans for the new bioassay facility should take this into account. A computerised system for storing and retrieving biological results should be introduced as soon as possible.

5. Modernisation of facilities for synthetic and analytical chemistry, and overseas training of pesticide chemists, are required and should be considered as a possible Phase III supported by UNIDO/ODA.

6. Biochemical studies on mechanism of action and selectivity of fungicides and other pesticides should be established at SRICI, as an aid to the discovery process.

7. SRICI should review the project management system to ensure effective integration of the chemical and biological effort, particularly when the two disciplines are at different sites.

8. An international seminar on a suitable crop protection topic, for example on pesticide resistance, should be held at Shenyang. Possibly this could mark the opening of the new biological facility. Funding from UNIDO or other organisations would be required, especially to support the attendance of overseas scientists.

1. Background

UNIDO - sponsored missions to China in July 1979, July 1980 and September 1983 initiated and developed a project which aimed to strengthen pesticide research and development at the Shenyang Institute of Chemical Industry (SRICI). This project was to be funded jointly by UNIDO and the UK Government Overseas Development Administration (ODA). SRICI work on pesticides comprises the identification and development of novel chemicals as pesticides, toxicological testing of existing and promising new compounds, and the development of processes to produce existing and new compounds for large-scale use in crop protection in China. Overall objectives are to increase the agricultural production of China and improve its efficiency, by increasing the range of action of indigenously produced pesticides, and to increase safety of use by replacing BHC and other less desirable pesticides.

Two phases of the UNIDO/ODA project were distinguished:

I Strengthening toxicology and pesticide synthesis
II Strengthening biological screening and further evaluation

Phase I included two linked projects: DP/CPR/80/008 funded by UNDP (US $164,650) and US/CPR/80/45 funded by UK-ODA (360,000), with UNIDO acting as the executive agency for both projects. These projects were intended to provide equipment for a new toxicology facility to be built at a green-field site near Shenyang, and for the programme of chemical synthesis, and funding for training fellowships and consultancies ('expert missions') related to toxicology.

Phase II included two further linked projects: DP/CPR/80/008 (extension) ($150,000) and US/CPR/83/286 ($452,000), to provide equipment for a new bioassay facility, also to be built at the green-field site, and to support fellowships and consultancies related to biological aspects of SRICI crop protection R and D.

An intention of moving eventually to the new site the entire pesticide research facility, including synthetic and formulation chemistry, was indicated in the report of the July 1980 mission.

2. Objectives of visit

The objectives were laid down by UNIDO as follows.

'The expert in addition to reviewing the actions taken on recommendations already made by previous experts should suggest:

- A consolidated programme for screening and biological evaluation (both in vivo and in vitro) of novel compounds as potential fungicides.
- Additional equipment needed to carry out efficient, reliable and reproducible screening experiments.
- Additional facilities needed to growth rooms to propagate and also collection and storage of fungal spores for inoculation.
- Procedure for documentation of laboratory results for logical comparison of efficacy of various compounds.'

3. Organisation and structure of visit

Of a total assignment of three weeks, 14 days were spent in China, 2 - 3 days travelling Bristol - Peking - Bristol, 1 - 2 days making arrangements and preparing lectures and information for visit, 1 - 2 days preparation of report, and 1 - 2 days de-briefing. In the event, these were found to be reasonable allocations of time to meet the objectives.

Because I had received much background information already, on advice from Drs. Holly and Lyon from their past experience as experts, and with agreement of UNIDO, the normal briefing visit to Vienna was omitted to save time for the other activities. I received some information and a request to obtain specific information on planned expenditure on equipment from Dr. B. Sugavanam, back-stopping officer in Vienna, by telephone shortly before departure. I had received relevant reports of earlier missions and original project description papers from Drs. Holly and Lyon, with whom I had informal personal contact. I had also obtained some useful information on the status of plant diseases in China from Mr. Hong Chuan-yi of SRICI, whom I met together with three of his colleagues and with Drs. Holly and Lyon, when the Chinese delegation was in London in January 1985. It was necessary to have all this background well in advance, in order to prepare lectures and gather relevant information on equipment and test procedures. Thus if I had not been able to obtain it informally (and to some extent fortuitously) a more detailed briefing by UNIDO well ahead of the time of the visit would have been warranted.

The first two days in China were spent in Beijing. During this period I had a short meeting with Mr. A.W. Sissingh, Senior Industrial Development Field Adviser for UNDP, at the UNIDO office, at which the objectives and organisation of the SRICI pesticides programme and the requirements of the present assignment were discussed. Priorities for the

visit and a provisional schedule of activities were discussed later with Mr. Hong Chuan-yi, who is Vice Chief Engineer of SRICI, and also General Manager of the China Nanshen Petrochemical Development Corporation at Nantong, near Shanghai.

The Director of the pesticide R and D programme of SRICI, Mr. Wang Daxiang, has been seriously ill for about six months. Although he is improving, it seems unlikely that he will be able to resume his duties. Mr. Hong Chuan-yi is at present acting Director of the programme, a difficult job for him since he must spend about 80% of his time in Nantong, with only 20% in Shenyang. He was my senior technical contact in China, devoted much time to my visit, and was present at most major discussions. Another person heavily involved in my visit was Mr. Shen Peide, Director of the Chief Engineer's office at SRICI, who is senior administrative officer for the pesticides programme; since Mr. Wang Daxiang's illness he has taken increasing responsibility for its management. Mr. Shen Peide also acted as my interpreter, and usefully for me he was formerly a fungicide chemist, with two years' experience at the University of California. I also spent some considerable time with Mr. Lu Zu-Yi, Head of the Bioassay Department, and Mr. Cui Dianchen, Joint Head of the Fungicides Section.

Of nine days in Shenyang, the first two were devoted to learning more about the pesticides R and D programme at SRICI, visiting all relevant departments, and also seeing the new 'green-field' site for Phases I and II development. I then spent two days in giving lectures (on 'Recent Trends in Plant Disease Control' and 'Discovery and Evaluation of Fungicides') and leading discussions on fungicide screening, evaluation and use. In the final three days I reviewed and advised on plans for buildings, facilities and equipment, interviewed candidates for six-month training fellowships in the UK, and led a final general discussion of the future priorities of the pesticides programme. A most useful visit to the Shenyang Agricultural College was also included.

Finally I returned to Beijing with Mr. Hong Chuan-yi and Mr. Shen Peide, and discussed the main points arising from my visit with Mme. Li Qiming Senior Programme Officer of UNDP at the UNIDO office. I left China on 11th July for London, via Japan. A four-day visit to Japan was arranged and funded by the Sumitomo Chemical Company, primarily to discuss research collaboration between Sumitomo and Long Ashton Research Station, but also to see facilities and research procedures of potential interest to SRICI.

4. Progress in Phase I (strengthening toxicology and pesticide synthesis)

Phase I has concerned mainly the development of improved toxicological facilities. I visited the toxicology building at the new 'green-field' site at De Sheng Yin, 17 km from SRICI, which is nearing completion. It has a total ground area of 0.3 ha, and there is a separate electricity sub-station, boiler house, water tower and staff restaurant. Occupation late in 1985 is envisaged. There are single-storey, large SPF animal breeding and maintenance areas, with filtered air input and output, connected to a double-storey laboratory block for examination of treated animals and metabolism studies. I am not qualified to comment on the design of the building as a toxicological unit; however, it has been built with much advice from toxicologists from the An-Pyo Toxicological Centre in Japan (a Japanese Government organisation). The facilities should allow for approx. 100 acute oral tests, 10 sub-acute tests and 1 - 2 long-term feeding tests per annum.

Regarding UNDP/ODA funded equipment, a Coulter blood analysis apparatus ($160,000) was temporarily installed and functioning at SRICI headquarters, pending removal to the new site; liquid scintillation equipment and a biological material oxidiser had recently arrived. A fish toxicity test unit was under quotation, but not yet ordered, and inhalation toxicity equipment was still under consideration at SRICI - if the fish toxicity equipment costs much more than the amount originally allocated, as it may well do, then the inhalation equipment may have to be purchased with Ministry of Chemical Industry (MCI) funds. Further details are given in Table 1. Computer equipment for Phase I has been obtained from Japan. Two SRICI toxicologists will visit Japan on UNIDO-supported fellowships in 1986.

Synthetic chemistry and formulation were at one time destined to go to the new site. Now, however, it is planned that they will stay at SRICI, both for financial reasons and because unavoidable pollution by effluents at the new site would be unacceptable. Biochemical laboratories may be established at the new site in the future, and an area of the land is allocated for this.

To support synthetic chemistry, a high vacuum distillation apparatus (ca. $20,000) for sample purification was purchased through UK-ODA funds and arrived one month ago.

5. Progress in Phase II (strengthening biological screening and evaluation)

(a) Balance and size of relevant R and D effort

SRICI has about 1,000 workers divided about equally between pesticides, dyestuffs and colour-film research. The Pesticides Division has about 350 people, partly distributed as follows (numbers of university or college graduates, where known, are given in brackets):

synthetic chemists	55 (50)
analytical chemists	40
formulation chemists	25
biologists	30 (6)
toxicologists	15
large-scale synthesis	50
environmental science (mainly residues)	20

Both chemical and biological efforts are divided roughly in the ratio 2 : 1 : 1 : 0.2 for insecticides : fungicides : herbicides : PGRs. Thus for fungicides there are at present about 12 organic chemists (8 synthetic), 5 formulation chemists, and 8 biologists.

(b) Provision of experimental chemicals and formulations

The throughput of novel SRICI chemicals for screening varies considerably, since effort is sometimes diverted to product or process development work. At present it seems to be in the range 750 - 1,500 chemicals p.a., with 150 - 300 of these dedicated primarily to fungicides. A number of natural products and potential dye-stuff and pharmaceutical chemicals are included in this throughput. There is an increased emphasis on natural products, especially those derived from higher plants collected from different parts of China. I said that world-wide experience in the chemical industry suggested 15,000 - 20,000 chemicals per annum might with reasonable luck give one commercially, agriculturally and environmentally viable new product. Thus the present relatively low throughput at SRICI is a matter of concern. The future rate is undecided, but even a provisional estimate could assist the scale of planning of new facilities.

Quantities of chemicals made initially for screening typically appear to be 5 - 10g (sometimes up to 100g) per chemical. With modified, smaller-scale formulation and biological screening procedures it should be possible to decrease this to 1 - 2g and hence to increase throughput to some extent.

Structural priorities in synthesis were not discussed for reasons of confidentiality, but considerable interests in glyphosate-based chemistry and in pyrethroid and OP insecticides were noted. Synthetic pesticide chemistry, under the leadership of Mr. Zhang Sunzho, is divided into 8 - 9 insecticide groups, 4 - 5 fungicide groups, 4 - 5 herbicide groups and 1 PGR group. Each group typically comprises 2 - 3 synthetic chemists, 2 - 3 synthetic technicians, and 2 - 4 analysts (to determine purity of starting materials, intermediates and final products).

Compounds appeared to be screened rather specifically, say against herbicides only. I stressed the need for all chemicals to go to all screens, because the nature of their biological activity cannot be predicted confidently and can vary greatly with minor structural changes (for example the fungicide metalaxyl originated as a herbicide candidate, and the fungicide ethirimol as an insecticide candidate).

Communication of results is at present done on an individual basis between particular chemists and biologists, by means of informal hand-written cards and notes. Introduction of standardised procedures, based on computer inputs and print-outs, including structural formulae and simplified biological results expressed as a numerical code, is recommended.. This would enable all workers involved readily to deposit, retrieve and study the results. A unified, printed card system could be used as a back-up in the early stages. A standard system of numbering experimental chemicals should also be introduced, to assist recording and retrieval; separate blocks of numbers should be allocated to chemicals synthesised at SRICI and to those obtained from outside sources.

Some modern analytical equipment was seen, much of which was in a separate analytical department. This included GCMS (Varian MAT 311A), IR (Perkin-Elmer), NMR (Bruker WH-90) and HPLC (mixed Chinese, LDC and Beckman equipment). Most GLC machines were of Chinese manufacture.

In general the design and the condition of the chemistry laboratories, which are of 1950 vintage, left much to be desired and would be unacceptable to chemists in the UK. In my opinion any further UNDP/ODA financial support, if available, should form a Phase III devoted to a refurbishment of the chemical facilities and to training fellowships and expert missions in pesticide synthetic and formulation chemistry. Very little of the Phase I support was used in the area of pesticide chemistry.

Up to 5 kg quantities of chemicals are normally made at SRICI in the synthetic research laboratories. This seemed large to me, and very time-consuming and disruptive for the exploratory chemists. In other organisations >200g quantities are made in separate large-scale units. At SRICI amounts between 100 kg and 30 tons are made in a pilot plant which I visited briefly. It employs some 50 persons, and at busy times night-shifts are worked. I think the establishment of a unit to undertake synthesis on a scale between that of the exploratory laboratories and the pilot plant should be considered.

Experimental formulations used at SRICI are mainly wettable powders (WP), emulsifiable concentrates (EC), or aqueous solutions according to the physical properties of the chemicals. I suggested that for water-insoluble materials bead-milling in small containers to give suspension concentrates might be more economical of material and more convenient than making WP or EC formulations. When the new facility is ready, it would probably be more efficient and convenient to do the storing, weighing and formulating of chemicals there rather than at the headquarters site, and risks of deterioration of the inevitably crude formulations during transport and storage would be lessened.

(c) Bioassay of fungicides

The laboratories for bioassay of fungicides and other pesticides, together with some other SRICI departments, were on a separate site some 15 minutes walk from the main SRICI facility where the pesticides synthesis and formulation departments and the library were situated. When the new facilities at De Sheng Yin are in use, the distance will be much greater and establishment of good communications between biologist and chemist through telephones, computer links, efficient transport of chemicals and regular meetings must be a high priority.

The fungicide laboratory has 8 people (6 graduates) under the joint leadership of Mr. Cui Dianchen (laboratory studies) and Mr. Shen Zhongyu (field studies). Initial screening is done entirely by in vitro tests. Some 20 compounds per month are tested at present, mainly in winter when field work is not done. Formerly some pot tests on cereal powdery mildew, rusts, rice bacterial blight and tomato late blight were done. Most unfortunately, the fungicide glasshouse facility has been destroyed to make way for a new training centre (mandatory for all industrial organisations in China under recent legislation). Therefore these pot tests are at present done by several different 'outside' organisations in other provinces. Routine in vitro screening at SRICI is done by agar plate tests on:

Fusarium oxysporum)	
)	cotton wilts
Verticillium dahliae)	
Gibberella zeae	maize stalk rot
Gibberella saubinetti	wheat scab
Rhizoctonia solani	(rice sheath blight
	(cotton sore-shin
Colletotrichum gossypi	cotton anthracnose
Pyricularia oryzae	rice blast

Approx.100 - 200 candidate chemicals per annum are tested, by incorporation in the agar at 200, 20 and 2 ppm.

During informal discussion, Mr. Cui Danchen and colleagues gave the following tentative rankings (1 = greatest) for glasshouse and field evaluation of chemicals, in relation to current major disease problems in Chinese agriculture. Not surprisingly the diseases for which chemical control is more difficult to find were considered the biggest problems!

Disease	Importance as a research target	Chances of success in finding an effective new chemical	Ease of testing (with current SRICI facility
Cotton: Fusarium	1	10	4
Rice: Xanthomonas	2	11	9
Cotton: Verticillium	3	9	3
Wheat: Erysiphe	4	8	11
Wheat: Puccinia gram.	5	7	10
Potato: Phytophthora	6	6	8
Rice: Rhizoctonia	7	4	7
Rice: Pyricularia	8	5	6
Wheat: Gibberella	9	1	5
Cotton: Rhizoctonia	10	3	2
Cotton: Colletotrichum	11	2	1

It should be stressed that the ease of testing refers to the current facilities and procedures at SRICI. When the new site is operative Erysiphe and Puccinia should be among the easier tests; none seems particularly difficult to do in vivo, except possibly Gibberella on wheat - this attacks mainly the ears, but a foliar test must probably suffice for early-stage screening. I am not fitted to judge the reliability of the column one estimates, but the SRICI workers seemed well in touch with the practical disease problems of the country and the needs for improved control measures, aided in this by a considerable amount of travel to do field trials in different regions and by contact with the Shenyang Agricultural College and with the net-work of official Crop Protection Research Centres that exist throughout China. The column two estimates are a matter of debate, and to some extent reflect current difficulties of testing rather than intrinsic problems; for example I would rate cotton Rhizoctonia as basically more difficult as a target than wheat Erysiphe. However, success against all these targets is feasible, and primary screening against the organisms covered is well worth-while. A much fuller list of important plant diseases in China, with major targets marked, was prepared by SRICI staff and is retained by me.

The fungicide laboratory was rather poorly equipped. For example, the chemical weighing room was unventilated, as was the dilapidated inoculating room in which a spirit lamp was used for aseptic transfers. The absence of any current glasshouse facility is lamentable, and must be rectified as soon as possible. Primary and secondary screening were not being done at the time of my visit, because the staff were engaged in field experiments.

Whilst the targets are realistic, the current fungicides testing programme at SRICI must be considered very unsatisfactory and the chances of success small. As mentioned previously (under 'Provision of Chemicals and Formulations') the throughput is very small compared with that of other organisations. It is essential that input of chemicals is increased greatly, and that the Fungicides Section should be able to do many more tests. All-year-round primary and secondary testing in the glasshouse and laboratory must be established, to match all-year-round chemical synthesis and provide continuous feed-back of results. The present system of diverting effort to field research in the summer period is not satisfactory. A separate field group should be established, preferably remaining within the Fungicides Section; the field group can certainly help in glasshouse work at times of the year when field work is not possible or not needed, but this should be seen as an extra contribution

to the continuous work of a core group of workers whose main commitment is to glasshouse and laboratory screening and further evaluation.

In vitro screening is generally accepted as a poor guide to field performance of fungicides. Tests against plant diseases are needed, to indicate better the potential disease control in the field and to indicate phytotoxicity at the primary stage. Re-introduction of tests on the obligate parasites and extension of in vivo testing to all the other target pathogens should be done as soon as possible; unfortunately this must await the provision of the new bioassay facility. Agar-plate tests can be run as a useful back-up to in vivo screening programme, and enable additional organisms (e.g. storage pathogens of fruit and grain) to be incorporated. I recommended the use of a multi-point inoculator and mixed-culture plates, to simplify the in vitro testing, and suggested that the 200 ppm rate could be dropped without risk of missing useful new compounds or leads.

There was much detailed discussion on developing fungicide screening techniques in the glasshouse and field, and on further evaluation tests for systemic movement, vapour action, persistence, etc., which I will not report in detail here. For primary screening, seedling plants grown in small pots (ca. 4 cm diam.) are very convenient to handle, take up little space and give good results. In initial tests, chemicals can be applied both as sprays and as soil drenches to the same plants, so that both protectant and systemic activities can be detected; if results are positive, the types of activity can be separated in subsequent tests. Suitable standard protectant and systemic compounds should be included with every batch of tests.

Problems of fungicide resistance were also discussed. Few if any problems have been clearly perceived yet in China, but inevitably they will arise and the widespread use of MBC sprays to control wheat scab seems a particularly 'high-risk' treatment. I stressed the need for early-stage monitoring of any new fungicide, to determine base-line activities in a number of different crops and regions, and the need to co-formulate 'high-risk' chemicals with appropriate companion compounds.

The value of biochemical studies on fungicide mode of action as a stimulus to chemical invention and as a component of resistance risk analysis was emphasised by me. This may become possible in due course, and an area at the new site has been ear-marked for a biochemical laboratory block.

The field-testing facility at the new site at De Sheng Yin will cover only 1 - 2 ha. This is useful, but will probably be too small and further acquisition of land in the area (said to be available) may well be necessary. The soil was very sandy, so that some results of seed and soil treatments may be atypical and comparison with other soil types will be needed. Importation of different types of soil onto small plots at the new site is envisaged. I observed that it was heavily infected by an Equisetum species of weed, and suggested that efforts to eradicate this deep-rooted weed should be started soon. At the moment the land is lying fallow, and cultivation and cropping could also usefully be started, provided that soil-persistent herbicides such as simazine are avoided.

Crops that could be grown at the new site include: rice, cotton, wheat, barley, sugar-beet, grape-vine, melon, apple, potato and various vegetable crops. All the higher priority disease targets could be established either at the new site or in the vicinity without too much difficulty. The humid, warm summer weather with intermittent rain is ideal for the development of many plant diseases, and the use of susceptible crop varieties with high nitrogen fertilisation will also encourage infection. In view of the strong interest in soil-borne pathogens such as Fusarium, Verticillium and Rhizoctonia, it would be advantageous to establish separate, fenced-off plots where these pathogens are introduced and encouraged to multiply. I emphasised the need for field screening to be done also at other sites in China, wherever possible, to check for relative performance of experimental and standard chemicals under a range of climatic conditions. The advisability of field-testing in a simple way several members of a group, rather than relying on glass-house tests to select out a single leading compound for a programme of field experiments, was also pointed out.

The major fungicides currently used in China are carbendazim (very widely used), dithiocarbamates (mainly maneb and zineb), PCNB (in cotton), copper (mainly Bordeaux mixture) and sulphur (dust and flowable formulations). Small quantities of captan, triadimefon and metalaxyl are also used. Most of the above materials are made in China, and the proportion imported fluctuates considerably. Clearly there is much scope for introducing more effective compounds, either through discovery or through the importation of local synthesis of modern fungicides discovered elsewhere.

(d) Bioassay of insecticides, herbicides and PGRs

Insecticides. Mr. Liu Tien Ming, in charge of insecticide, acaricide and nematicide research, showed me the insect rearing. This is done on a small scale, in one room with only partial temperature control. Some 30 - 50 compounds a month are tested against eight pests (mosquito, army worm, house-fly, bean aphid, cotton aphid, cotton red spider mite, rice borer, locust). As with fungicides, testing was at a low ebb due to the demands of field trials, which are done throughout China in collaboration with other organisations. A list of major insect pests in China, with priority research targets marked, was given to the author and passed on to Dr. Geering.

Manufacture of BHC and DDT has been banned recently in China, and more OPs, carbamates and pyrethroids used instead. Simpler, cheaper alternatives to current pyrethroids are particularly sought.

Herbicides. The herbicides laboratory was not visited because the staff of four (headed by Mme. Wang Gui-Yun) were away doing field trials. A list of important weed problems in China, with priority research targets marked, was obtained by me and sent to Dr. Copping. Screening and evaluation tests are mainly soil treatments, on maize, rice, wheat and crucifer plants. The top three weeds in China are probably crab grass, barnyard grass and goosefoot. Much chemical weeding is now done and commonly used herbicides are nitrofen, alachlor, butachlor and 2,4-D. A little glyphosate is used, but not paraquat. Most spray application, as with other agrochemicals, is by hydraulic 'knapsack' sprayer.

Plant growth regulators (PGRs). Mr. Chen Hubao and three colleagues conduct PGR tests, and one small glasshouse is at present available. An experiment was in progress on cotton, where two candidate compounds were sprayed in order to inhibit vegetative shoot growth, and improve rooting and boll production. Another experiment was on sugar-beet, treated in order to increase the sugar content. A third test was aiming to interfere with the reproduction of certain toxic grasses that grow in S.W. China. This is a recently introduced programme, and the biological and chemical effort is relatively small at present. Throughput of chemicals seemed to be very small, but three chemicals with interesting activities were under detailed study.

A list of perceived PGR targets for China, with current priorities marked, was obtained and passed to Dr. Copping. Chlormequat is used to some extent in China to strengthen wheat and rice, GA on potatoes (apparently to suppress sprouting) and ethephon on cotton to accelerate boll formation and defoliation.

(e) Fellowships

UNIDO/ODA funds are ear-marked for six further fellowships - two for toxicologists to go to Japan in 1986 and four for biologists. Training in all four biological disciplines is required - in the management and the technology of primary screening, further evaluation and field screening programmes. I interviewed the following candidates.

Mr. Zhou Liang-Jia, aged 32, assistant plant pathologist. Has wife and one child. Worked on farms during cultural revolution. Majored in plant protection at Shenyang Agricultural College (SAC), in 1982. Does bioassays in greenhouse and field. Studied English at agricultural college and one year at Xian Language School. English fair - good.

Mr. Zhao Rijin, aged 29, assistant entomologist. Married. Wife expecting first baby in September. Worked on farms during cultural revolution. Majored in crop protection at SAC in 1982. Special interest in acaricides and nematacides (including control of mite Petrobia latis in wheat in central China). May become acaricide specialist in near future, but general insecticide knowledge needed. Studied English at SAC, six months at Xian and one year at NE Institute of Technology at Shenyang. English good.

Mr. Sun Xue Ying, aged 37, assistant PGR scientist. Married. Two children. After two years on farms, he taught maths at schools for 8 years. Then four years at SAC, and majored in Agronomy in 1982. Concerned with PGR selection in laboratory and field. Studied English at NE Institute of Technology for 6 months. English fair.

Mrs. Li Xue Yan, aged 29, assistant herbicide scientist. Married with a one-year-old daughter (whom grand-mother can look after). Four years farming, then at SAC graduating in 1982 in Agronomy. Does herbicide evaluation in glasshouse and field, using mainly soil-applied materials. English learnt only at SAC. English poor.

All the candidates were considered by senior SRICI staff and by me to be suitable for training fellowships in the UK; further English training is needed by all candidates, and especially for Mr. Sun and Mrs. Li, before coming to the UK.

Possible placements and timings of six-month fellowships were discussed tentatively, subject to further discussion during subsequent consultant visits and to acceptance by the Directors and appropriate supervising staff at the Institutes concerned. Possible timings are:

Zhon : Fungicides	May - Nov. 1986
Zhao : Insecticides/acaricides/nematicides	May - Nov. 1986
Sun : PGRs	May - Nov. 1987
Li : Herbicides	May - Nov. 1987

SRICI colleagues suggested a March - September timing. This is quite feasible and would allow a season's field testing. However, attendance at the BCPC Conferences at Brighton, which are held in mid-November, would be of great benefit to the fellows. Conveniently these are on 'Pests and Diseases' in 1986 and 'Weeds and PGRs' in 1987. A May - November period should still permit adequate field experience, including some autumn sowing and treatment.

During my visit I suggested that Long Ashton Research Station might act as a basic centre for the fungicide, herbicide and PGR fellows, and Rothamsted Experimental Station for the insecticide fellow (possibly with a period at East Malling Research Station to cover his acaricidal interests). However, this requires further discussion with the other consultants after their visits since (contrary to my earlier understanding) there are now indications that certain industrial companies (e.g. ICI, FBC Ltd.) might accept fellows for most if not all their training periods. More extensive training in laboratory and field screening methods and in the organisation of industrial pesticide R & D programmes could be gained by spending several months in industrial laboratories, with shorter periods at the public-sector institutes.

Full funding for travel (including attendance at BCPC Conferences at Brighton and other scientific meetings), subsistence and bench fees will be sought from UNIDO. Extension of the budget until 1987 will be needed for two fellowships.

(f) Equipment

SRICI indicated that US $452,000, including 13% UNIDO administrative charges, was provided by UK/ODA (through UNIDO) for project US/CPR/83/286

(Phase 2) and $150,000 by UNDP for DP/CPR/80/008 (extension for Phase 2). Of these sums, $307,000 and $102,500 respectively (total $409,500) were allocated to equipment, the remainder being used for expert visits, study-tours and fellowships. Proposed allocation of equipment, with notes on status of plans to purchase, is given in Table 1 (Annex 1). According to the UNIDO budget, these purchases should be made between January 1985 and December 1986, but postponements may be sought for certain items where installation must await completion of the new building (e.g. controlled environment equipment).

I gave advice on controlled environment (CE) equipment, having had experience of the suggested Fisons equipment at Long Ashton. Fisons now produce to order walk-in CE rooms, and I passed on some information on specifications and approximate price. These could be more economical in space and running cost, and more convenient to use for certain test systems. Controlled humidity is particularly useful where reproducible chemical uptake from the soil is required. I agreed to contact Fisons on my return to the UK, to obtain information needed on installation, servicing, spare parts, etc.

Additional equipment recommended for fungicide research is a humidity chamber (100% RH), to permit infection from droplets containing spores. Perhaps this could be constructed locally and I said I would send on relevant information and plans from Long Ashton where such apparatus has been constructed and is used routinely. Purchase of a modern inoculation cabinet, with fitted vertical air-flow to aid preparation of cultures and for in vitro tests, is recommended, and I said I would obtain information from Long Ashton.

I recommended that the Phase 2 computer system for data recording which is to be centered at the new site should link to the synthetic chemistry laboratory at the old site, and incorporate chemical structures as well as biological results.

(g) Buildings

A large laboratory and glasshouse complex for bioassays is planned for the new site at De Sheng Yin. Preliminary drawings had been made and I was given copies. There were many useful features, but I was concerned about the siting of the CE and application facilities which were remote from the glasshouses, and also about the arrangement of the glasshouses themselves. I suggested some major re-arrangements, which will be considered by SRICI, and discussed with the other consultants.

There is much to be said for a large open-plan area for CE, application and incubation equipment, placed directly adjacent to the

glasshouses, and for an adjacent block for offices, laboratories for cultivation of insect and fungal pathogens and microscopic work, field laboratories and stores, computer centre, library, etc. I advised that storage of experimental chemicals and small-scale weighing and formulation for glasshouse tests should all be done in this block, rather than at the old site. An increase in the allocation of space for CE equipment, including some provision for possible later expansion of these facilities, may be needed. In the preliminary drawings offices of senior scientists were placed together on a separate floor from the laboratories; juxtaposition of offices and relevant laboratories is much preferred, to encourage good contact with and supervision of more junior staff.

The glasshouses were to be aligned from East to West, abutting onto a brick structure on the North side, to save heat during the severe winter with its cold North winds. If the throughput justified it, a further parallel row of glasshouses, again with a brick corridor along the North side, would be built. I believe an alternative arrangement of glasshouses on a North-South basis would probably be no less heat-efficient, allow more uniform lighting and permit easier expansion if needed. Glasshouse benching will be metal (more flexible than the traditional concrete used in China) and some automatic sand-bed watering would be tried to check for efficiency and cost. Wet-pad cooling will not be possible, because the summers are too humid, and refrigeration is too expensive. Straw blinds may be the only palliative measure to be used against summer heat, although only one month was said to be excessively hot. Internal fabric blinds should also be considered. Adjustable-height, sodium lighting is planned.

Architect's advice would be sought shortly, but final decisions would be delayed until the first two fellowships in the UK were completed. It was originally hoped to start building early in 1986, with first occupancy in early 1987, but a half - one year delay is now inevitable. The proposed building plus land plus an adjacent field testing plot will cost the MCI approx. $1.6m.

(h) Management and priorities of the pesticide programme

Aspects of management were discussed briefly, and to some extent this drew on my own experience of project co-ordination and management of multi-disciplinary departments. It is essential that the whole programme of SRICI pesticide research has firm direction from a leader - formerly Mr. Daxiang Wang, at present Mr. Hong Chuan-yi and probably Mr. Shen Peide in the near future. Under Mr. Shen Peide would be the heads of the biological and chemical research areas, and under each of these the leaders of the four biological disciplines and of the synthetic chemistry

groups. The need for project leaders to co-ordinate the work of interacting biological, chemical and other units was emphasised by me; for example fungicide research will involve chemical synthesis, formulation, laboratory screening against plant diseases, small-scale and large-scale field trials, patenting and toxicology. Workers in all these disciplines need to produce a joint written progress report and to discuss it with senior management at say six-month intervals. Informal but regular meetings, say weekly, between biologists and chemists to discuss results and further action are vital, particularly since these two groups will be at separate sites.

One disturbing feature of the current organisation is that both the synthetic chemists and biologists engaged in exploratory work from time-to-time become totally involved in development work for considerable periods. The production and field-testing of relatively large amounts of material can seriously interrupt the inventive process which should continue steadily with continuous interaction between chemists producing novel candidates and biologists feeding back test results. At the time of my visit the laboratory and glasshouse screening appeared to have 'ground to a halt' because it was the season for field trials. Some distinction between 'exploratory' and 'development' chemists and between 'exploratory' and 'field' biologists needs to be made in my opinion.

This is one way in which throughput of chemicals could be increased - an urgent need. Reduction in the amount of chemical initially made and improved facilities for chemical synthesis (Phase III?) would also aid throughput. Acquisition of chemicals from other sources (pharmaceuticals, dyestuffs, natural products) should be encouraged as much as possible.

For fungicide research top priorities must be: the establishment of routine primary screening against the major plant disease targets in pot tests, rather than on agar plates; the re-establishment of further evaluation tests in the glasshouse or plant growth room; the field-screening of promising chemicals in 'micro-plot' trials at Shenyang and at other sites if possible.

SRICI staff keep in touch with international developments in their disciplines mainly through the scientific literature - there is an excellent library at the Institute. However, in addition to the six-month training fellowships, more direct contact of SRICI scientists with overseas workers needs to be encouraged by attendance at conferences, sabbatical visits, and publication of results in English-language journals wherever possible. I suggested the idea of holding a small symposium or workshop

on some suitable crop protection topic (control of cotton or rice pests/diseases/weeds? resistance to chemicals in pests/pathogens/weeds?) at Shenyang. This was considered attractive; some funding by UNIDO, FAO, or other organisations would have to be sought. This would be an excellent way to mark the opening of the new biological facility of SRICI!

(i) Further consultancies

Mr. Hong Chuan-yi told me that the appointments of Dr. Copping and Dr. Geering as herbicide/PGR and insecticide/acaricide/nematicide experts respectively had been agreed. They could visit together or separately, according to their own wish, and early-September or late-October 1985 would be the best periods. Apart from general advice on test procedures and facilities, their inputs on the selection and placing of fellowships and on the planning of the new building are urgently needed. To help in this, draft copies of this report have been made available to them, and an informal meeting in the UK with myself and Drs. Holly and Lyon will be arranged, if possible, prior to their visit. The advisability of an 'expert' visit by a synthetic pesticide chemist has been mentioned earlier in this report. I myself would hope to keep in touch with progress in the fungicide research and with more general aspects of the project, both through having some of the trainees at Long Ashton, through correspondence with SRICI colleagues and through a further visit if possible, perhaps in about two years time when the new facilities are coming into use.

6. Visit to Shenyang Agricultural College

Situated about 20 Km from the centre of Shenyang, this College is one of the leading agricultural colleges in China. It was founded in Shanghai and moved to Shenyang ca. 1950. There are some 1,500 students and 800 staff. I visited some of the teaching laboratories, research laboratories and field experiment plots, and was impressed by the general standard of work and by the knowledge and enthusiasm of the staff. I noted that fifteen plant growth cabinets with controlled temperature, lighting and humidity had been designed by and were in use at the College.

Professor Wu You-San, Senior Plant Pathologist, described the four main areas of plant pathology research:

(i) Wheat stem rust (Puccinia graminis). This is a very serious problem in Manchuria. Physiologic races have been studied for 18 years, and many new ones have been detected.

(ii) Multiple disease resistance in wheat. The aim is to gain reasonable levels of resistance concurrently against stem rust, leaf rust, powdery mildew and scab. Stocks resistant to each individual disease are available, and progress is being made in achieving multiple resistance. Resistance to root rot (Helminthosporium sativum) and to aphids is also needed, but adequate genetic sources have not yet been identified.

(iii) Physiology and biochemistry of powdery mildew, rust, and other cereal diseases. The role of enzymes (peroxidase, isoenzymes) is studied, and also the use of assays for the toxin produced by H. sativum to determine the resistance of wheat varieties.

(iv) Diseases of medicinal plants grown in China. Methods of control are studied in field experiments. Sclerotinia rot of gentian root ('ginseng') is a major target.

Professor Wu You-San said that Septoria spp. caused problems in wheat in certain provinces in some years. It may well spread in future, with more intensive cultivation and new varieties. Eye-spot and take-all occur, and are important in Shandung Province. Of the seed-borne diseases, loose smut (Ustilago tritici), flag smut (Urocystis tricici) and bunt (Tilletia foetides and levis) occur in wheat, but are not very serious and seed treatments are not widely used. A seed treatment against H. sativum would be useful, but mercury is banned and other effective treatments have not been identified. Professor Xu Yong Feng showed me the excellent herbarium of plant diseases of China, which is used for teaching purposes. Professor Li Jin, who specialises in Chemical Crop Protection, confirmed that carbendazim, made in China, was sprayed on a wide scale to control scab in wheat and barley, mainly in the more southerly wheat areas. No resistance to carbendazim had been detected yet. Forecasting of the need for treatment, through scouting for scab infection, was done widely.

In rice, blast and bacterial blight were major problems, especially in the south. Several blast fungicides were used (edifenphos, IBP, Rabcide, isoprothiolane) but bacterial blight control depended on partially resistant varieties. Sheath blight was controlled by validomycin produced in China (Chingamycin).

In cotton, Fusarium and Verticillium attack the roots at all stages of growth, and the most widely grown cotton variety is particularly susceptible. Crop rotation is the only control measure practised at present.

Herbicides are used widely in rice, which is mostly transplanted. Pre-emergence and post-emergence treatments are used, particularly Alachlor. This is also used in peanuts. There is concern about the carcinogenic properties of Alachlor, and alternatives are being sought. There is some use of 2,4-D in wheat.

As mentioned early in this report, organochlorine insecticides have been banned, and OPs, carbamates and pyrethroids are applied widely. Insect forecasting is now done in all major crops, through the national network of research stations, as a guide to insecticide application. Army worms, corn borers and aphids (in sorghum, soybean, wheat, etc.) are large problems.

Professor Dai Zhong-Lian, Senior Entomologist, said that research on aphid dynamics had started recently. He would welcome contact with UK workers in this field, and I said I would send on relevant reprints from Long Ashton. Direct damage by aphids seems generally to be a larger problem than virus damage.

7. Itinerary

Wednesday, 26 June: 1000 departed Heathrow flight BA003 for Beijing.

Thursday, 27 June: 1530 arrived Beijing. Met by Mme. Zheng Youzhu of Ministry of Chemical Industry (Foreign Affairs Department) and taken to Xiyuan Hotel.

Friday, 28 June: Met Mr. Hong Chuan-Yi (General Manager of China Nanshen Petrochemical Development Corporation, Vice Chief Engineer of SRICI, Director of SRICI Pesticides Project in absence of Mr. Wang Daxiang). Discussion with Mr. Albertus Sissingh (Senior Industrial Development Field Adviser for UNDP) at the UNDP office. Drew subsistence funds for the visit. Visited Temple of Heaven.

Saturday, 29 June: Visited Great Wall of China at Juyongguan Pass and Ming Tombs.

Sunday, 30 June: Planned schedule with Mr. Hong Chuani-Yi. Flew from Beijing to Shenyang by CAAC. Met by Mr. Wong Xie-Ming (SRICI Administration Officer, responsible for international and national visitors) and Mr. Hu (pesticides project technical supervisor). Taken to Liaoning Hotel.

Monday, 1 July: Welcomed at SRICI by Mme. Huang Jian-mei (Vice-President), Mr. Shen Peide (Director of Chief Engineer's Office), Mr. Lu Zu-Yi (Head of Bioassay Research) and colleagues. Discussed objectives of visit and schedule, and exchanged information on pesticides research at SRICI and Long Ashton Research Station. In afternoon visited the new site at De Sheng Yin, and toured the Toxicology Building.

Tuesday, 2 July: Visited SRICI laboratories for bioassay, analytical chemistry and synthetic chemistry, pilot plant and library.

Wednesday, 3 July: Gave lecture (2 hours) on Recent Trends in Plant Disease Control (Mr. Hong Chuan-Yi introduced me, and Mr. Shen Peide acted as interpreter). In afternoon led information discussion on priorities in fungicide research in China, including dealing with potential problems of fungicide resistance. About 12 persons were present. Banquet in my honour, hosted by Mme. Huang Jian-mei and colleagues.

Thursday, 4 July: Gave lecture (2 hours) on Discovery and Evaluation of Fungicides. In afternoon led discussion on fungicide research at SRICI in relation to agricultural needs in China, and to present and planned facilities, organisation and procedures at SRICI.

Friday, 5 July: Visited Shenyang Agricultural College, together with Mr. Lu Zu-Yi, Mr. Zhou Liang-jia (assistant plant pathologist) and Mr. Chen Yuan-Lu (assistant technical supervisor). Taken to the Imperial Palace, and to a concert of popular music.

Saturday, 6 July: Interviewed four candidate biologists for training fellowships in the UK, and later reviewed equipment needs for pesticides project, together with Mr. Hong Chuan-Yi, Mr. Shen Peide and Mr. Lu Zu-Li.

Sunday, 7 July: Visited Benxi Water-Cave, and picnicked by Prince River (with Mr. Shen Peide and colleagues). Saw agricultural activities en route.

Monday, 8 July: Discussed plans for the new bioassay building and associated facilities, with Mr. Hong Chuan-Yi and colleagues. Visited Tomb of Ching Emperor.

Tuesday, 9 July: Final meetings with Mme. Huang Jian-mei, Mr. Hong Chuan-Yi and colleagues.

Wednesday, 10 July: In morning flew by CAAC to Beijing, with Mr. Hong Chuan-Yi and Mr. Shen Peide. Met Mme. Li Qiming (Senior Programme Officer for UNDP) at UNDP office to review my SRICI visit and discuss reporting arrangements. (Mme. Li Qiming was deputising for Mr. Sissingh, who was away from the office.)

Thursday, 11 July: Departed from Beijing Airport, by a Panam flight to Tokyo, for a separate, brief visit to Japan (at invitation of Sumitomo Chemical Company and Institute of Agro-Environmental Research).

8. <u>Acknowledgements</u>

I wish to thank all those whom I met in China for the excellent co-operation and hospitality which I received, and in particular Mr. Hong Chuan-Yi and Mr. Shen Peide who gave me much of their time and much personal assistance.

Table 1

SRICI: Purchases of Equipment

Item No.	Description	Quantity	Estimated total cost and funding source ($)	Department	Phase	Use	Status and comments (July 1985)
1	Stereomicroscopes (one with camera)	2	10,000 UNDP	Bioassay	2	Observation of tissues	Decision on models not yet made
2	Optical microscopes (one with camera)	2	10,000 UNDP	"	2	"	Arrived one month ago
3	Environmental control equipment						
	(a) Climatic cabinet (FE 300)	6	38,000 -95,000 ODA	"	2	Tests on crop pests, diseases and weeds	Quotations requested one month ago through UNDP Beijing. Decisions on humidity and other specifications not yet made
	(b) Large growth cabinets (FE 2340)	4	94,000 ODA	"	2	"	
4	Controlled environment chamber (FE 600H)	4	24,000 UNDP	"	2	PGR research	Quotation requested
5	Application equipment						
	(a) Plant test spraying machine (R.E. Engineers Ltd., London)	1	16,000 ODA	"	2	Pesticide application in screening tests	Quotation requested (note 6 l min. capacity seems large)
	(b) Microapplicator (Burkard PAX 100)	1	1,200 ODA	"	2	"	Quotation requested
	(c) Potter spray tower (Burkard A 520)	1	1,600 ODA	"	2	Insecticide testing	Quotation requested

5	(d) Kearns-Marsh knock-down chamber (Burkard)	2	2,100 ODA	"	2	Insecticide testing	Quotation requested
	(e) Large deep-freeze cabinet (60 cu.ft. Raven Scientific LH)	1	2,500 ODA	"	2	Storage of biological samples	Quotation requested
	(f) Electronic balances (Sartorius, 1712 mp 8 and 1412 mp 8)	2	3,000 ODA	"	2	Weighing chemical samples	Quotation requested
6	Spectrophotometer	1	(10,000) ODA	"	2	Obtaining bio-chemical data for herbicide research	Now to be omitted and obtained by local purchase with SRICI funds
7	High vacuum distillation apparatus	1	20,000 ODA	Chemical Synthesis	2	Preparation of pure samples	Arrived one month ago
8	Liquid scintillation apparatus	1	30,000 UNDP	Toxicology	1	Metabolism studies	Arrived one week ago
9	Biological material oxidizer	1	30,000 UNDP	"	1	Metabolism studies	Arrived one month ago
10	Fish toxicity test unit	1	> 10,000 ODA	"	1	Provision of fish toxicity data	Quotation requested
11	Inhalation toxicity test equipment	1	20,000 ODA	"	1	Provision of inhalation toxicity data	Under consideration; may cancel if fish toxicity test unit is very costly
12	Other equipment to be specified later*		97,000 ODA	-	-	-	-

*Mainly computer hard-ware and soft-ware for Phase 2. The SRICI Computer Laboratory can advise on systems. An inoculation cabinet (say $4,000 - 5,000) may also be required.