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REPORT OF THE TAC MISSION
TO REVIEW THE AGRICULTURAL ENGINEERING PROGRAMME OF THE
INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)

(Agenda Item 4)

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REPORT OF THE TAC MISSION

TO REVIEW THE AGRICULTURAL ENGINEERING PROGRAMME OF THE

INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)

Rome, June 1975

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This report is based on notes prepared for discussion with the Director and staff of the Engineering Department of IRRI and takes into consideration their reactions and the findings derived from subsequent visits to countries of the Asian region.

i. The mission concludes that an engineering research and development programme forms and should continue to form a valid and worthwhile part of the core programme of the Institute and is impressed by the fact that the programme is production-oriented and has achieved a measurable degree of success in getting some of its designs accepted for manufacture.

ii. Furthermore it recognizes the fact that, of necessity, IRRI's agricultural engineering department must become involved in extension activities as a logical and essential adjunct to its research and development programme; a "two way" flow of information and ideas being vital to success. Such activities contribute to its strength and account for the unique status of the IRRI programme in engineering circles when compared with that of other national and even international institutions.

iii. The mission feels that too much emphasis has been placed, in the recent past, on engineering prototype machinery, particularly tillers, for production, and that this has affected the flow of new designs. It is felt that, now that a systems approach to the evaluation of needs for mechanization has been adopted, including a product planning process, much greater emphasis can be placed on developing machinery for the farmer and implements for prime movers rather than on the prime movers themselves.

iv. With the foregoing in mind, future research objectives should be firstly directed towards the development of second and third generations of existing successful designs to ensure advancement of technology in different areas. For example the current work on seeders and fertilizer equipment should logically lead to the development of more efficient multi-purpose seeder-cum-fertilizer units with possible upland crop applications.

v. In developing new designs the maximum use should be made of existing technology and mechanisms which can be adapted for simple low cost applications. For example, had existing technology in respect of seed cleaning been more thoroughly studied then a suitable design for an oscillating cleaner might have been developed at an earlier stage with less input of time and resources.

vi. As regards field testing and evaluation the department should concentrate on testing its own designs for performance, together with selected items of commercially available machinery directly relevant to its development programme. Service testing of industrial production models of IRRI designs should be minimized, with the ultimate aim of phasing out such testing in favour of national institutions or the manufacturers themselves.

vii. The mission has made detailed recommendations regarding priorities in the report, which, broadly speaking, endorses the present and proposed programmes, with the exception that the whole question of soil tillage and levelling should receive renewed attention, including upland requirements, as this is fundamental to the efficient performance of other field machinery. As regards the development of a four-wheel tractor, work should concentrate on the development of a suitable range of equipment using an available single design of a four-wheel tractor as a test bed.

viii. In view of the probable expansion of activities of other Southeast Asian institutions in the field of post harvest technology it is recommended that the department confine itself to those aspects directly concerned with the needs of the small rice farmer or the village miller. The work on low-cost simple crop driers is considered to be of prime importance.
ix. Any demand for work on animal equipment or machines suitable for other crops, arising from the multi-cropping programme, should be considered for inclusion in the programme only if the work involved is directly related to the existing or future rice machinery development programme.

x. The embryo programme of development of irrigation equipment should be continued with special reference to the needs arising from the Water Management and Control programme.

xi. As regards field transportation and handling, work should be primarily restricted to those aspects directly concerned with crop handling and the reduction of field losses at harvesting. Such work should not develop into a general exercise on rural transport.

xii. The mission has noted the relative success achieved in placing on the market the power weeder (Japan only), the power tiller and the axial flow thrasher. It feels however that recent efforts at extension have taken up too much time of senior staff to the detriment of the core research and development programme.

xiii. Various types of contact are seen to be necessary for effective extension according to national circumstances, such as Departments of Agriculture and Industry, Investment Boards, National and International Research Institutions (including Universities) and representatives of industry. This was confirmed during the mission’s visits to other countries. Although, in the past, direct contacts with industry have proved effective, it would be unwise to place too great a reliance on this type of contract, particularly in countries where the public sector is dominant. In the long term benefits must be conditional on the establishment and maintenance of complementary close and sustained contacts with appropriate government institutes and other agencies.

xiv. The proposed USAID assistance with industrial extension is welcomed as reflecting the line of approach to extension suggested by the mission, but it should not be unduly biased towards success in attracting manufacturers. The list of objectives outlined in the USAID project document, relating to market evaluation, comprehensive testing and adaptive design and development work on IRRI machines, being of equal if not greater importance.

xv. In general, proposals for assistance from other sources should be welcomed, provided they come under the general control of IRRI and are effective in promoting their interests in other countries in a manner complementary to the USAID project. The possible interest of the ASEAN group in this area has been noted.

xvi. The mission endorses the recent reorganization of the department along more rational and functional lines whereby emphasis is given to a systems approach to development on the one hand and the setting up of a product planning section on the other. This constitutes a commendable change from an "ad hoc" approach to research and development to a more programmed approach, whilst retaining desirable flexibility.

xvii. The current and proposed (1976) levels of resources available to the department appear to be adequate in relation to the programmes envisaged. Any major increase should only be considered in the event of a major breakthrough in technology requiring considerably enhanced resources for implementation.

xviii. The mission commends the recent increase in activity under current training programmes but stresses the need for rather more formalization of curricula. It also notes the inability of the department to attract post-doctoral fellows, and recommends that, in the field of engineering, candidates with Masters degrees, appropriate experience and proven ability should be considered as suitable for the award of fellowships. The importance of training as part of extension activities to spread the IRRI philosophy and approach to evaluation, design, testing, production and marketing can hardly be over estimated.

xix. Whilst noting that a considerable degree of cooperation existed between the engineering staff and those working on other programmes, the mission believes this should be extended through more formal links, even a degree of integration, with the cropping systems
programme. This is particularly appropriate in the light of the recent reorganization of the agricultural engineering department.

xx. Ways and means should be found, possibly through adequate subcontracting of appropriate projects, to improve the working relationships between IRRI and UPLB in the field of post harvest technology. The mission believes that such subcontractal arrangements should be applied equally to joint projects as well as any which might in the future be subcontracted in total.

xxi. In regard to farm mechanization links with other international centres, the mission feels that IRRI has much to offer and could itself benefit from a mutual exchange of ideas and materials with the Agricultural Engineering Sections concerned. This would be of particular value in relation to development of equipment within a multi-crop programme.

xxii. The mission records its support of the network approach to the establishment of an Asian Coordinating Centre for Agricultural Machinery. It feels that IRRI could well benefit from the establishment of a viable and active programme of this nature, but stresses that every effort should be made to avoid unnecessary duplication of IRRI's machinery programme. This could most easily be effected if any regional structure created could concentrate its responsibilities on areas not already covered by IRRI's programme and if it were sited more centrally, in an area relevant to those responsibilities.

xxiii. Whilst unable to decide on the best approach, regionally, to the question of postharvest technology research (as between the proposals of IDRC and FAO), the mission endorses the need, as expressed in both of them, for a coordinated regional activity in this field. Formulation of a joint proposal for such an activity, in which IRRI's programme at the village level should not be duplicated, should, in the opinion of the mission, be undertaken by the several potential donors meeting to achieve common ground.
REPORT OF THE TAC MISSION TO REVIEW THE AGRICULTURAL ENGINEERING PROGRAMME

OF THE INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)

CHAPTER I

INTRODUCTION

1. The Agricultural Engineering Department of the International Rice Research Institute (IRRI) has been conducting, since 1965, a USAID funded special project (cod 2541) entitled "Equipment Development for Tropical Rice Cultivation". An advisory group meeting was held at IRRI in March 1974 to evaluate the progress and future plans of the project. The group concluded that the project had demonstrated measurable success in developing and introducing appropriate small scale mechanization technologies, particularly in the Philippines, and that the IRRI agricultural engineering programme should be strengthened through expanded core budget funding and separate subcontracts for production extension in high priority countries.

2. One consequence of these recommendations was the proposal to transfer the activities of the equipment development project to the core budget of IRRI from 1975 onwards. This proposal was reviewed by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) at its Eighth Meeting in August 1974. Although members of TAC recognized that the offer of the former sponsor of the special project to make an increased core contribution would more than cover the costs of the additional programme, the principles of the operation, and the validity of machinery research as a core operation, were called in question. Initial reaction to the proposal was decidedly negative, some members pointing out the low pay-off realized to date in terms of off-take of machinery, relative to the costs of the programme. It was recognized however that because the programme suffered from the drawback of being outside the manufacturing sector and thus unable to compete with commercially available equipment, there was a need for some form of entrepreneurial activity to help close the gap between research and its application. Other members felt furthermore that if the commercial sector was not in fact able to supply equipment adapted to specific local needs, or unwilling to finance high risk operations on its development, there could be scope for a strengthened machinery research programme with concomitant industrialization programmes. Time had not permitted a detailed study of the proposal, and the Committee therefore concluded that an evaluation of the machinery programme and an analysis of the level of adoption of improved equipment was necessary, before a decision could be taken regarding endorsement of the transfer of the project to the core programme of IRRI.

3. At the same meeting of the TAC it had been decided to initiate a quinquennial in-depth review programme of the activities of all the International Centres with a review of IRRI's activities late in 1975. The TAC therefore undertook to charge its main review team with a special evaluation of the machinery research programme, to meet the needs expressed above. It was subsequently decided to mount the machinery programme review separately, and earlier, in order that the findings of the mission could be reported to the TAC and CGIAR/Centres' Week meetings in July 1975.

4. The Ninth Meeting of TAC held in February, 1975, examined proposals for regional post harvest technology research activities in Asia, which took cognizance of the work of IRRI in the field, and foresaw considerable advantage in the close association of IRRI with any internationally sponsored activities in the field. It was not prepared to take a decision on these proposals however, pending the visit of its review mission, and decided to expand the terms of reference of that mission to include an examination of proposals for research in post harvest technology prepared by IRRI itself, by FAO and by IDRC of Canada. It also considered it desirable for the mission to give specific attention to the ESCAP/UNDP project proposal for the establishment of an Asian Coordinating Centre for Agricultural Machinery, a proposed site for which was at Los Baños, Philippines, in the close vicinity of IRRI.
Terms of Reference of the Review Mission

5. The terms of reference of the mission, as approved after due discussion with the Director and appropriate senior staff of IRRI, are attached hereto as Annex I.

Composition of the Mission

6. The personnel of the mission were selected with a view to achieving a balanced composition and a mix of competences in the fields of engineering science, machinery design, manufacture and farm mechanization. The team was as follows:

- B.P. Potheary - Team Leader - International Consultant in Agricultural Engineering and Land Development, Colchester, England
- C.G.E. Downing - Director, Agricultural Engineering Research Service, Department of Agriculture, Ottawa, Canada
- Lee Kun Tatt - Chairman, Singapore Institute of Standards, Singapore
- W.J. van Gilst - Agricultural Engineer, Agricultural Services Division, FAO, Rome, Italy
- B.N. Webster - Secretary - Deputy Executive Secretary, TAC

Itinerary

7. The itinerary originally planned, in discussion with IRRI staff, made provision for an examination of IRRI's machinery research programme, a background briefing on the relevance of that programme to IRRI's overall mandate, and for field visits in the manufacturing sector at village and industrial level in selected countries where the products of IRRI's research were being introduced. The mission decided, early in its stay at IRRI, that more time would be required at IRRI Headquarters to effect a worthwhile review of the programme. The stay at IRRI Headquarters was therefore lengthened by one full day. It was also decided to rearrange the visit to Bangkok to permit a planned visit to ESCAP. The countries originally selected were Thailand, Indonesia, Sri Lanka and India. Although it was later thought to be not possible to include Indonesia, due to communication difficulties between Indonesia and Sri Lanka, this was subsequently proved possible by dividing the mission after the visit to Thailand into two parties, one of which visited Sri Lanka and the other Indonesia, the parties then reuniting for the visit to India.

The itinerary finally followed is attached hereto as Annex II.

Acknowledgements

8. The mission wishes to express its deep appreciation of the assistance and hospitality offered by the numerous people with whom discussions were held and whose names are recorded in Annex II. In particular a special debt of gratitude is owed to the following:

- Dr. Nyle Brady, Director IRRI, Drs. Amir Khan, Bart Duff and Don Keuther of the Engineering Department, IRRI, for their assistance in planning and rephasing of the itinerary of the mission, both in the Philippines and the other countries visited.
- Dr. Ben Jackson, Rockefeller Foundation, Bangkok, and Dr. Chak Chakkaphak, Agricultural Engineer, Department of Agriculture, Bangkok, for planning and organizing the itinerary of the mission in Thailand.
Dr. Robert Jackson and Mr. Dadang Tarmana for planning at short notice a revised itinerary for the mission's visit to Indonesia.

Mr. Ram Katther for assistance in planning the itinerary of the mission in Sri Lanka.

Shri Shradh Patel for assistance in facilitating the visit of the mission to India.

The FAO Regional Office for Asia and the Far East in Bangkok, the FAO/ESCAP Joint Division staff, Bangkok, and the FAO Country Representatives in Indonesia and Sri Lanka for their general assistance and contributions to the mission's briefing.

CHAPTER II

THE CONCEPT OF AN INTEGRATED APPROACH TO AGRICULTURAL MACHINERY DEVELOPMENT

9. In the mission's view the Agricultural Engineering Department of IRRI has developed a unique approach to the development of machinery and equipment for the small rice farmer. The concept directly involves various sectors of the community, namely the farmers themselves, small and medium manufacturers, Government institutions concerned with mechanization development, those involved in improved rice production technology, cropping systems and water management programmes. This "total" approach is best illustrated by the situation in the Philippines where, by virtue of IRRI's location at Los Banos, both agricultural application and industrial development of IRRI's designs are most advanced.

10. The past years have seen a gradual evolution of the concept from the early days, when the most obvious needs were tackled on an ad hoc basis, with consequent undesirable dispersion of effort. It now embodies a much more rational approach to design, involving more accurate determination of farmer needs in a variety of situations and countries, followed by the preparation of detailed specifications and target costs prior to the actual design process. Liaison with industry in the Philippines has directly involved IRRI in design, not only for performance but also for production. Whilst the latter is desirable up to a point, local factors in each country such as the availability of labour, materials, skills, and production facilities will determine the precise form in which any given IRRI design will be produced, even though performance and basic specifications remained unchanged.

11. The mission has noted, based on its previous experience, that the vertically and horizontally integrated approach, now followed by IRRI, contrasts favourably with the narrower approach often found in national institutes, where the design of prototypes is seen as an end in itself, largely unrelated to the agricultural system into which they have to be fitted, or to the potential or need for local manufacture.

12. It is for these reasons that the mission strongly supports the continuation of agricultural engineering research and development as part and parcel of IRRI's core activities. Furthermore, due to IRRI's international status, any programme of work undertaken would remain static and incomplete if it were not maintained by an extension effort designed to bring to the farmer in neighbouring rice growing countries any concrete results of the research and development programme. It could be argued that the industrial aspects of extension are quite outside the normal range of activities for an international research institute, but whilst the mission has recommended some curtailment and rationalization of this activity it remains convinced that links with all types of manufacturing units are vital to the maintenance of a smooth flow of production oriented designs. For this reason the mission considers the USAID supported industrial extension project an essential concomitant to the core programme.

13. In the small farming sector to which IRRI is directing its attention — which, incidentally is poorly served by the international agricultural machinery industry — the level of technology is not high, so that adaptive development based on existing mechanisms and designs is more appropriate than basic research.
14. Whilst acknowledging the unique status of the IRRI agricultural engineering programme, the mission was made aware, during its visits to the other countries, of the tremendous activity already going on in this field. For example, power tillers to non-IRRI designs are being made in several countries as well as hand-weeders and threshers. IRRI therefore, through its extension programme, should keep abreast of such developments, avoid duplication of effort and maybe even capitalize on the successful introduction of designs in one country by adapting them and spreading those adaptations to others. Through their training programmes and contacts by their own or contractual personnel, they can foster and aid such developments and in particular their philosophy and approach to evaluation, design and production engineering, can serve as a model for other national, regional and international institutions.

CHAPTER 3

RESEARCH AND DEVELOPMENT

15. The main objective of the Research and Development Programme to date has been for the development of simple, small size equipment to satisfy the needs of the small rice farmer in the 1 to 10 hectare size range, which could be manufactured, maintained and operated using local manpower and industrial resources. The main emphasis has been on the modification and adaptive design of existing machines and principles, with little activity on background research. Considerable effort during the past few years has been on the industrial extension of such machines through local small to medium size manufacturers.

16. The various operations of the programme have been diffused as a machine has been modified, tested, manufactured, re-designed, demonstrated and re-evaluated, finally getting into the hands of the farmer, rejected as unsatisfactory, or still in some state of development. It is therefore necessary to look at the state of individual machines, rather than the various operations, to assess progress.

17. Although the greatest impact and growth in manufacturing IRRI designed machines has occurred in the Philippines, some development and production has occurred in nine other countries. (see Table 1).

<table>
<thead>
<tr>
<th>COUNTRY/EQUIPMENT</th>
<th>SEEDERS</th>
<th>BELLOWS PUMP</th>
<th>GRAIN CLEANER (ROTARY)</th>
<th>DRYER BATCH TYPE</th>
<th>POWER TILLER 5-7 H.P.</th>
<th>AXIAL FLOW THRASHER</th>
<th>POWER WEEPER</th>
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<td>395</td>
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TOTAL NUMBER OF MACHINES - 22,384
18. **Power tillers:** Major success has been achieved with the 5-7 hp tiller which was developed to match, at lower cost, the performance of the simpler imported power tillers. It is being produced by 12 companies in six Asian countries. A number of companies have modified the original design to suit their manufacturing practices. Development work is being carried out by IRRI and a number of companies to incorporate steering clutches in the unit.

19. A 10-12 hp tiller has been released to six Philippine companies for limited production. This machine is equipped with a diesel engine, three forward and one reverse speed gear transmission, and steering clutch. IRRI plans to test the industrial prototypes. It is felt that inadequate attention has been given to suitable implements for the power tillers.

20. **Axial flow thresher:** An axial-flow drum-type thresher of 1 ton/hr capacity is being produced in eight countries by a number of manufacturers. Some are producing only one or two to be used for evaluation and demonstration. IRRI and a number of companies are doing development work on the unit to adapt it for threshing wheat and other crops such as sorghum and soybeans. Work on a smaller portable version of this machine is also proceeding.

21. **Rotary power weeder:** This three-row, one to 1 1/2 hp engine powered machine has been produced by a company in Japan since 1971. This company has developed a wide range of attachments for the machine, which is being sold for weeding and cultivating both lowland and upland fields, mainly in Japan where the small farmers are in general more able to afford heavier capitalization.

22. **Tractor lug wheel:** An extendable lug wheel has been developed combining desirable features of the fixed steel blade wheel and an adjustable wooden strake wheel as used in Malaysia. This adaption is being used quite extensively in the Philippines on the larger four-wheel tractors used for paddy cultivation and other wet field conditions.

23. **Batch dryer:** The IRRI design of this unit is adapted from a Japanese farm-level batch dryer. The unit can be easily fabricated by most metalworking shops and consists of a grain bin with a perforated floor and a fan-burner assembly. Six companies in the Philippines and one in Taiwan are manufacturing this unit.

24. **Rice hull furnace:** A rice hull furnace consisting of an inclined grate burner, a hopper for rice hulls and an ash trap, has been developed for use with the batch dryer, and prototypes are being produced by some manufacturers in the Philippines.

25. A number of units, such as the single-hopper paddy seeder and multi-hopper paddy seeder have only been fairly successful in commercial acceptance. Others, such as deep placement granular fertiliser applicator, deep placement liquid chemical injector, contact herbicide applicator and grain moisture meter, are just in the introductory stage of commercial production and a degree of acceptance cannot be determined, but it is likely that the multi-row, deep placement granular fertilizer applicator, currently in the introductory stage of development, will bring the most demand.

26. Three machines, the drum-type paddy thresher, table-type paddy thresher and rotary power grain cleaner have been unsuccessful in meeting the farmers' needs and interests.

27. Adaptive design and remodelling are continuing on a 3 m. wide rotary tiller for large tractors, rotary harrow for small tractors, anhydrous ammonia applicator, oscillating screen grain cleaner, vertical axis windmill and a solar energy collector. Most of these have reasonable potential as viable commercial units.

28. An appreciable amount of effort is being spent on the development and fabrication of a four-wheel, 15 hp riding tractor. Further intensive work on this prime mover is inappropriate as there are a number of these being developed by manufacturers in the region.
Emphasis should be placed on the development of appropriate implements for such units as they become available on the market. This would ensure that they would be utilised efficiently for specific tillage, transport and harvesting operations, not only for paddy operations but also for upland multi-crop needs.

29. Some background research is being carried out on the stripper harvester, tractor PTO-driven thresher, Engleberg rice milling machines, jet and tubular pumps. All of these have good potential for near-future utilization, with the exception of the stripper harvester. Further work on this should be minimal until a feasibility study has been completed on the adoption of a standard cutter-bar system to the axial flow thresher.

Economic Aspects of Research and Development

30. Power sources: A study recently undertaken states that animal power remains a viable economic alternative on small farms of up to 4.2 hectares. The use of the hand power-tiller remains the least-cost alternative for farms of 4 to 50 hectares. The larger four-wheel tractors are preferred above the 50-hectare size. The mission noted that in this particular study no account was taken of custom operations. It also doubts whether the hand power-tiller is the most appropriate power source for farms of over 15 ha.

31. Experimental results to date show that yields are not significantly different for an equivalent number of horsepower hours per hectare for land preparation, either from tractors or from water buffalo.

32. Soil tillage: The mission feels that relatively little attention is being given to soil tillage practices (wet as well as dry). Knowledge of the influence of various soil tillage practices, with various types of tillage implements on soil structure, mobility of various machines and weed population, are essential to the selection and development of the most appropriate soil tillage implements. Questions requiring attention are:
   i. Under what water (moisture) regime should tillage be carried out?
   ii. When should tillage be done and what time should elapse in between tillage and planting?
   iii. What is technically, as well as economically, the best type of tillage?

33. Planting: Comparing different methods of seeding indicates that while broadcast seeding itself is inexpensive, unless it is carried out in conjunction with a number of other required practices (notably weeding) yields are often lower than those attained with transplanting. Manual transplanting remains the optimum choice for very small farms with adequate manual labour available. As size of farm increases and labour cost rises, direct row seeding supersedes manual transplanting.

34. Weeding: A comparison between handweeding, manual Japanese rotary weeder, and the IRRI-designed power weeder, indicates that hand weeding is the least-cost method for areas of less than 0.1 hectare. Between 0.1 and 6.0 ha, the manual rotary method is the least-cost technique. The IRRI-designed power weeder does not become economically viable until the area increases to around 6 hectares. Both the power and the manual weeder have application where rice is sown in rows.

35. Threshing: The manual threshing with the use of "hampasan" or threshing frame, and pedal thresher, are relatively labour-intensive, resulting in a sharp rise in cost as their use increases. The McCormick-type thresher requires large capital outlay and a large volume of grain consolidated for threshing, to be an attractive alternative. It has severe limitations of being unable to thresh wet paddy or to move readily to inaccessible locations. The IRRI-designed table thresher increased labour productivity but with a rise in fixed costs. It was intended to replace manual threshing at an output of around 60 tons per year and was expected to find its greatest market in areas where high yields were obtained, where high labour costs were encountered, and where double-cropping was practised. It did not however find farmer acceptance. The axial flow thresher is best adapted to the larger farmer and the custom operator.
Mechanization and Employment Research

36. The initial steps toward mechanization of the rice sector, stimulated by government policies and the introduction of the new rice technology, has not yet resulted in any major labour displacement. Reduced labour requirements for land preparation due to the shift to the use of tractors, have been more than offset by increased labour requirements for weeding, harvesting and threshing.

37. Increased production of the IRRI machines has resulted in new industrial employment in the countries where these machines are being produced. As of December 31, 1974 seven manufacturers in the Philippines had reported the hiring of over 700 additional workers, directly in the manufacturing operation. These jobs were created at an additional capital investment of only US$ 200 per person. This activity has resulted in the creation of additional jobs in production-related activities, of material procurement, management, marketing and servicing operations, for which no figures are available. Many of the IRRI machines are being used in contract operations, creating employment at the farm level, but it is difficult to estimate the overall impact this programme has on employment.

Testing and Field Evaluation

38. Test and field evaluation studies have been conducted on a wide range of IRRI and other commercially available machines to establish performance, design criteria, power and labour efficiencies, with the primary purpose of assessing their ability to satisfy the needs of tropical Asian farmers. Extensive field evaluation of IRRI prototype machines, before and after their release to manufacturers, to pinpoint operational and production defects, was a continuing programme. Based on these evaluations, recommendations were made for changes in the design or production processes as required.

39. Power tiller survey: A survey was conducted to determine the technical factors which influence the selection and utilization of power tillers. The data gathered will be used to establish parameters for future tiller designs. The survey also evaluated technologies employed by local tiller manufacturers and included personal interviews with power tiller owners and manufacturers.

40. The farmers' choice of a tiller was mainly influenced by the presence of local dealers and by the make first introduced into his area. Cost and availability of spare parts influenced his choice very little. Heavy weight and the resulting handling difficulty and the high incidence of belt, steering clutch, and engine failures were major complaints of the owners.

41. Thresher: A field study of rice threshers used in the Philippines was made to determine which machines were best suited for small and medium size farms. Machine features such as oscillating screen, rotary screen, number of threshing drums and blowers, etc., were evaluated in terms of performance.

42. The results indicated that machines with a single drum, blower and separator (similar to the IRRI axial flow thresher) are desirable in that they combine high output per horsepower and man-hour with minimum losses.

43. Rice transplanter: A locally manufactured hand-operated transplanter was field tested to determine performance. It planted five rows at 20-cm spacing. Seedlings per hill varied widely, spacing between hills was highly variable because it depended on the operator's judgement.

44. A Japanese engine-driven transplanter was evaluated to determine its suitability for Philippine conditions. Maintaining straight rows was difficult due to the imbalance caused by the oscillating seedling carrier.

45. Rice miller: The "kiskisan" (Engleberg) mill is widely used throughout Southeast Asia but has fairly low recovery rates. Tests were performed to determine potential modifications to improve milling efficiency. Initial tests on a production model showed 63
to 65 percent total recovery and 25 to 30 percent head rice recovery. Modifications to the screen, cylinder, blades and discharge produced total and head rice recoveries of 66-68 percent and 33-35 percent, respectively. Additional testing is planned with the intent to provide modifications that can be inexpensively incorporated into not only new production but also mills already in use.

46. The mission feels, in the light of its review of the research and development programme to date, the visits to industry and their reactions and the planned increase in the Industrial Extension Programme, that the core engineering activities should be more experimental in nature, with greater emphasis on background research related more to the type of equipment needs of the wide variety of cropping conditions, than to the hard-ware of the machines.

47. The introduction and growing acceptance of large power tillers and four-wheel tractors will require a broader range of implements, so that power units can be more fully utilized, particularly under multi-cropping practices. The development of power units as such should not be a part of the IRRI core programme except insofar as modification might be required to suit implements and accessories being developed. Emphasis should be on suitable special, as well as multi-purpose, implements for such types of power units.

48. There is a growing need for experimentation on all aspects of basic tillage, soil preparation and levelling, so that fertilizer placement, seeding and weeding can be accomplished more efficiently. This is essential as more intensive cropping practices develop in the upland as well as lowland growing areas. In these studies it will be important to assess the different practices and machines in relation to energy input as well as on the normal cost/benefit ratios based on production.

49. The exceedingly high crop losses that occur during cutting, field drying, handling, threshing, storage and milling demand extensive studies on improving equipment associated with all these practices. Field transportation equipment should be included in this area of work also. Harvesting and threshing studies will need to be carried out in all rice producing countries because of the great number of varieties grown and extreme variations in harvesting conditions, to ensure suitability of types of equipment needed. Because of the high losses during cutting and multiple handling of the crops, a future need will be for a small combine which will reduce these losses appreciably and, at the same time, allow growing of varieties which thresh more easily and efficiently. In the meantime, further development of the PTO thresher will be a valuable contribution.

50. Rice post-harvest technology includes drying, procurement and testing for quality determination, storage, parboiling, milling, grading and rice by-product utilization.

51. The agricultural engineering department of IRRI has been placing greater emphasis on post-harvest problems but will limit its efforts mainly to farm and village levels; this is fully endorsed by the mission. Three aspects of post-harvesting problems will be examined:

(a) Farm level practices; a technical/economic survey will be carried out in various areas in the Philippines and Thailand during both cropping seasons of the year.

(b) Village level drying and processing practices which will be simultaneously carried out with the programme mentioned in (a).

(c) Improvement of equipment presently in use such as (i) village level drying equipment, including utilization of low-cost energy sources; (ii) continuation of improvement of the design of the steel huller (Engleberg) which is commonly used in many countries in Asia at village level (small millers); (iii) improvement of a low-cost grain cleaning machine.
There are a number of special areas in which advanced development should be made. The increase in use of fertilizer, herbicides and pesticides and their higher cost, requires equipment that will accurately and efficiently place these products for maximum utilization. Land levelling equipment suitable for the small farm areas could make a significant impact on the more efficient use of irrigation water. In conjunction with this, consideration needs to be given to the further development of low-cost mechanically powered irrigation equipment using wind energy or other sources of power available on the farm.

The testing and field evaluation programme should continue, but with emphasis being minimized and shifted from the extensive service testing of prototype and production models of manufacturers, to more performance and functional evaluation of a wider range of equipment. The national testing institutions and the manufacturers themselves are more appropriate and more suitably located for such extensive activities on, often, their own prototypes.

CHAPTER 4
MANUFACTURING DEVELOPMENT AND FARM APPLICATION

A fundamental aim of IRRI's research and development work on small farm mechanization is to design items of machinery or equipment widely acceptable to the small farmer in Southeast Asia, and which can be manufactured and marketed in a number of countries. Thus, throughout the design and development process, account is taken of the engineering capability and skills likely to be available, with special reference to conditions prevailing in the Philippines, where a wide range of engineering enterprises can be found. In other countries not only will the capability of the light engineering industry show differences but the basic requirements of the farmer may differ in certain aspects.

These facts highlight the importance of an extension programme which will not only propagate the results of the IRRI developments and give support to local manufacturers, but will also keep local requirements constantly under review and bring them to the notice of IRRI for use during the design process. It is not suggested that IRRI can design equipment applicable to every rice and multi-cropping situation in Southeast Asia, where local factors and practices appear dominant then the national institutions should be encouraged to take on IRRI's local development role with the initial guidance of IRRI itself. In its early years the extension programme concentrated on locating suitable manufacturers who were interested in producing IRRI designs.

It was soon realized that distributing the engineering drawings and technical information to manufacturers was, in itself, not sufficient for commercialization, as small and medium-sized metalworking firms in the developing countries, who are potential manufacturers of simple agricultural equipment, are not too familiar with engineering drawing practices and prefer to work with prototype machines. Thus, a design release procedure was developed under which both engineering drawings and a prototype machine were provided to interested manufacturers who saw an immediate potential for developing additional business at little or no risk. Such a strategy was possible because most IRRI machinery designs were quite simple and did not require any special tooling, materials, and processes in the initial small batch production.

The manufacturers were given a completely free hand to modify the IRRI machinery designs as they saw fit, to suit their production facilities or to improve performances, and it is interesting to note that almost every IRRI machine underwent some design modifications and improvements at this stage. Their first machines were then submitted to IRRI for a series of tests to ensure that they met performance specifications, and they were informed of any problems encountered during the tests. Modifications and improvements were made in the machines at the Institute before they were returned to the manufacturer. As soon as satisfactory performance was obtained with any prototype machine, it was returned to the manufacturer to serve as a guide for future production.
58. This design-release strategy has proved rather successful and is now being followed as a standard procedure for the release of all IRRI designs. The relatively small capital required in purchasing a few machines has played a significant role in attracting the manufacturers to produce IRRI machines and in minimising their risks. In the Philippines, at least, the competitive urge has resulted in material improvements over the original design; in the case of the power-tiller, styling has played an important part.

59. Due to the limited resources of the programme it was not possible to organize an independent international effort for commercializing the machines in countries other than the Philippines. Cooperative linkages were developed in nine other Asian countries, with organizations that have similar interests, to evaluate and extend machinery designs in their respective countries. Under a subcontract programme IRRI provided prototypes of those machines which were commercially successful in the Philippines together with a modest amount of funding for hiring personnel. The subcontractor's responsibility was to evaluate and adapt the machines for local conditions and to encourage local companies in commercial production of the machine. The engineers employed by the subcontractors were provided with a short training at IRRI, to familiarize them with the full range of machines available from the programme and the production techniques utilized by the manufacturers in the Philippines.

60. Because of the industrial nature of this activity, most cooperative subcontracts were made with non-academic institutions. It was felt that universities in Asia did not have sufficient contacts with local manufacturing firms, and the chances for commercialization through academic institutions were thus not too good. Many of the subcontractors were government machinery research and testing institutions or commercial firms engaged in the production of agricultural machinery or related products.

61. It was found that the agricultural engineering research and testing organizations in the public sector were primarily interested in testing and evaluating machines under local conditions. These institutions also suffered from a lack of interaction with local industry, lack of adequate resources, and were not sufficiently motivated in the commercialization of farm machines. A number of visits were made to government and industrial workshops handling IRRI models (for details see Annexes II and III).

62. The mission believes it covered a fairly representative cross-section of industries in the countries visited. The general comments and reactions of the industrial people were of approval and satisfaction with the IRRI programme as it has developed. They also indicated confidence in the basic suitability of most of the units developed for production so far, and were quite complimentary on the enthusiasm and cooperation of the IRRI staff.

63. There were somewhat diverse opinions as to the continuing role of the IRRI programme. The small companies were quite satisfied to continue to receive working drawings or well tested prototypes to copy, with IRRI staff supplying some of the production engineering needs of their small companies. They also indicated that they would like to have IRRI continue to test their production model machines. The medium sized companies did not feel that IRRI should spend very much time in testing their prototype machines, except to determine their functional suitability under various conditions. They were satisfied to receive either general drawings or the loan of the prototype machine. They indicated that, from their experience so far, they would redesign many of the components to suit their production techniques and perhaps add some features to give a competitive advantage on the market.

64. Most of these companies were doing field testing but indicated they would like to have IRRI do a test on their final production model to more or less check against their testing procedure, and to be used for advertising purposes. They felt IRRI could assist in market analysis of new machines, assisting them in adapting new designs to their particular manufacturing facilities, to help in obtaining assistance from government agencies for testing and demonstrating the machines in farmers' fields, and in obtaining scarce resources for manufacturing.

65. The large companies were quite definite in their views as to IRRI spending much time on production engineering design activities and intensive testing of production machines.
They were satisfied that their engineering staff were more capable of doing this for their particular company and that what they would look for would be general design of new types of machines or significant improvements for existing machines. They would like assistance on market analysis and advice on availability of consultants for special production problems, such as balancing crankshafts or other dynamic or complicated components of machines.

66. IRRI has now recognized the need for an organized industrial extension effort so as to capitalize on the progress already made. An industrial extension contract is now being negotiated as a special project with USAID/IDR, Washington, under which engineering teams will be stationed in selected developing countries to test and adapt the IRRI machines for local conditions and to encourage and assist manufacturers in the production of these machines. An industrial liaison engineer will also be added to the core machinery development programme at the Institute, to provide background support to the industrial extension engineers located in other developing countries, and to the cooperative organizations that are working with IRRI in the industrial extension activities in other countries.

67. The organizational chart in Fig. 1 shows the inter-relationship of these extension activities with other activities of the agricultural engineering department and other IRRI programmes. The mission does however recommend that senior staff of the agricultural engineering department, and others outside the industrial extension programme, should continue to be associated with this aspect of the work to ensure the "two-way" flow of ideas and information so essential to the research and development programme. Care must be exercised to avoid over-involvement in extension work by core staff, as this appears to have retarded progress in the vital research and development programme in recent months.

68. The USAID project proposals embody most of the requirements for a successful industrial extension programme but the mission hopes that not too much stress will be laid on attracting large numbers of manufacturers, or on the number of machines actually produced in any one year. It feels that, in the long term, the quality of the contacts made is more important than quantity and is happy to note that many facets of extension, other than production links, are included in the project's terms of reference. The mission does have some reservations as to the location of one of the industrial extension engineers in Pakistan. At first sight it would not appear that IRRI has much to offer a country whose rice is exclusively produced under irrigation in an otherwise arid climate. It is recommended therefore that an early study be made of the relevance of IRRI designs to the small rice farmer in Pakistan, taking into account the Government's policy as regards mechanization and the existence of a strong light metal industry already producing equipment for Pakistan's agriculture.

69. Whilst the rationalization of the extension programme is welcome, the need for flexibility remains, as exemplified by the very wide range of conditions encountered in the countries visited by the mission, and the different industrial policies being followed. Under the new arrangements IRRI remains dependent on outside donors for the industrial extension programme, a vital part of the agricultural engineering department's activities. Although other potential donors than USAID are known to be interested, the current sub-contract system could be strengthened in countries where a full-time IRRI staff member is not as yet warranted. Malaysia, and possibly Indonesia, might however qualify for a full scale extension effort, and here there are possibilities of using the industrial network set-up by the ASEAN group who have ready access to bilateral and regional aid funds. One advantage of using the ASEAN network would be their intimate knowledge of the countries concerned and their ability to monitor progress and overcome administrative and procedural bottlenecks.

70. However, before the extension programme is expanded beyond the proposed USAID project, the mission feels strongly that IRRI must review the number of designs it has for immediate release and how far they have a proven market in the various rice growing countries. As mentioned earlier it also feels that some impetus has been lost in the core research and development programme, possibly due to the over-involvement of senior staff with extension and with production technology. In the long run though the recent
rationalization of core activities, with the addition of an engineer to undertake market research and product planning, can only enhance the effectiveness of the industrial extension programme, and ensure that designs have wide acceptability from the outset and thereby reduce the incidence of "non starters" or designs with low impact.

CHAPTER 5
DEPARTMENTAL ORGANIZATION AND MANAGEMENT

71. A review of past, present and future activities of the agricultural engineering department of IRRI has been undertaken in Chapters 2 to 4. These also examined the philosophy and approach to research and development work as well as industrial extension aspects. These concepts must be reflected in an adequate departmental structure which places due weight on specialized activities whilst, at the same time, ensuring both internal and inter-departmental coordination. In this connection the current organizational chart of the department has been reproduced as Fig. 1 (page 12).

72. This chart incorporates the latest changes made as a result of a recent accession of senior staff, and assumes that the proposed USAID project for support to industrial extension (see chapter 4) will become active. The latter project will provide the three senior staff required for industrial extension, one of whom will play a coordinating role and will be located at Los Banos.

73. Broadly speaking the organizational chart reflects the thinking outlined in earlier chapters although the mission has recommended even closer links with parallel IRRI programmes such as cropping systems, irrigation and water management and soil and crop management for rice. This could be effective through the medium of the mechanization systems section and, in fact, a large measure of cooperation already exists.

74. The mechanization research section has a leading role to play in guiding and establishing the parameters within which the design engineers work. In turn it depends heavily on the mechanization systems section, together with the findings of other IRRI programmes (e.g. cropping systems) and information from the extension programmes, to establish its planning data, including priorities. It is not suggested that it should become the sole source of ideas for inclusion in the design programme, but that it should establish procedures which will confirm the validity or otherwise of proposals from other quarters. Above all it must be practically oriented, paying attention at all times to the needs of the farmers.

75. In the past the design engineering section has been effectively lead and activated by the department head in person, and there is no reason why this arrangement should not continue. The main differences in the future will be that, as the systems and research sections become more effective, they will influence the activities of the designers to a greater extent, hopefully along the more restricted lines recommended in chapter 3. In particular more extensive field testing of prototypes, both within the Philippines and in selected countries outside, could help radically to improve the success ratio with manufacturers and ensure early acceptability at farmer level.

76. The industrial extension programme has been discussed extensively in chapter 4, and mention has been made of the need for flexibility, in the light of the variety of agricultural situations to be found in rice growing countries and the nature and strength of their respective institutions and manufacturers. The general approach to manufacturing developments and farm application is reflected in the organizational outline, with the hope that other agencies might finance additional programmes in, or on behalf of, the selected countries which are ripe for development. The choice of Pakistan as a principal location for extension has been questioned, as it is felt that the IRRI programme may only have limited relevance to an essentially dry country where rice is grown wholly using irrigation water.
77. The importance of the training courses, together with the production of engineering drawings and publications, can hardly be overstressed. Increasing reliance, in the future, on national institutions and national manufacturing units to evaluate, test, modify, re-engineer and conform machinery to local markets, must be based on a constant interchange of information with the core programme at Los Banos and a series of specific training courses designed to impart IRRI's philosophy and experience to national personnel.

78. The mission therefore broadly endorses the proposed organization of the department, and considers that the core funds and resources available, and proposed at the time of its visit, are adequate to implement a worthwhile and progressive programme of investigation, analysis, research and development. Whilst these funds allow for some measure of extension activity by core staff, the main support for such activities must come from outside sources and hopefully, as the needs warrant, other donors will be found willing to support extension programmes in parallel to that of USAID.

CHAPTER 6
TRAINING AND RELATED ACTIVITIES

79. The importance of training programmes, seminars, workshops and individual contacts with the IRRI agricultural engineering department, have assumed considerably greater importance in recent years as the extension programme has increased in scope and content. It is now impossible for IRRI senior staff working within the core programme to maintain personal contact with the numerous agencies, institutions, government departments and interested manufacturers involved all over Asia, without serious interruption of their main function. Yet some direct contacts with the core programmes, in support of the work done by the extension staff, is essential.

80. There are many ways of maintaining such contacts without making excessive demands on the time of IRRI core staff, and several have been used by IRRI in the past to supplement the wide dissemination of information sheets and publications which has been a feature of the agricultural engineering programme to date. Such contacts can be broadly classified under three main headings namely:

- training courses undertaken as part of a formal education programme or of a post-graduate or post-doctoral nature;
- training courses relating to specific aspects of IRRI's work such as design, field application, testing or production technology;
- those made during the holding of workshops or seminars when a two-way flow of information is maintained.

81. Whilst the first of these should continue to form a regular part of the IRRI programme, the work undertaken, in the form of projects or theses, should be directly relevant to the main core departmental programme, and participants should make a direct contribution to progress or increase in knowledge. In this connection the mission believes that, as doctorates are perhaps less common in the engineering disciplines than biological disciplines, consideration might be given to accepting a Masters degree and adequate professional experience to fill this cadre, which has not so far attracted many candidates.

82. It is the second aspect of training which is likely to assume far greater importance in the future. If IRRI is to spread its philosophy and approach to mechanized agriculture at governmental and institutional level in Asian countries, then one of the best ways is to bring selected key personnel from those countries to Los Banos for short courses relevant to their particular interests. This is so in the areas of analysis of farm needs, product planning and prototype testing, with industrial liaison, production
engineering and marketing coming next in importance. The proposal to establish an Asian centre, under the ESCAP/UNDP project for support to national institutions engaged in farm mechanization research and development, would materially assist IRRI in this field.

83. The holding of seminars and workshops can play a vital part in promoting IRRI's role in farm mechanization development and already participants have included those from several countries outside Southeast Asia. It is suggested that the most valuable contacts made in this way will, in the long run, be with institutions, both international, regional and national, which are concerned with multi-cropping mechanization problems. Too much emphasis on seminars and workshops on design engineering and manufacturing problems, at the expense of performance analysis, product planning and field application, is likely to be detrimental to IRRI's long term interests as a research and development centre. The strong links established with manufacturers in the Philippines should be used as examples for others to study, in the light of their local circumstances, rather than as a blueprint for IRRI's extension activities in other countries. The diversity of situations, as encountered by the mission during its brief tour through Southeast Asia, must be expected to be reflected in a diversity of training needs.

84. As regards the duration of various courses offered by IRRI, those of a student or immediate post-graduate nature will be determined by individual circumstances. Short specific courses should run for 2-4 weeks only, as senior and technical grade staff from overseas are unlikely to be available for longer than this period, and it is essential that the regular programme of work at IRRI should remain uninterrupted for as long as possible. Secondment, either to the agricultural engineering department or to local industry in the Philippines, should be encouraged, providing the numbers involved do not become unwieldy.

CHAPTER 7
INTERACTIONS OF THE IRRI AGRICULTURAL ENGINEERING PROGRAMME WITH OTHER INTERNAL AND EXTERNAL ACTIVITIES

International Relationships

85. The mission noted with satisfaction that a commendable level of cooperation was maintained between the staff members of the engineering department and those of other departments of IRRI. Believing that this necessary cooperation could be enhanced through more formal links with other programmes, contacts to date appearing to have been on a more informal personal contact basis, the mission endorses the proposed linkages shown in the organogram (Fig. 1, page 12) of the restructured engineering department. It also believes that, as mentioned in chapter 5, even closer ties might be achieved through a degree of integration with the cropping systems programme. This would help to ensure the necessary guidance being given to design engineers by the agronomists of the cropping systems programme, regarding specific requirements for tillage and subsequent agronomic operations.

Links with Other International Centres

86. The mission believes that IRRI's machinery development programme has much to offer the other international centres, particularly those concerned with cropping systems research for small farm systems, such as ICRISAT and IITA. It foresees possible overlap occurring, especially in equipment for multi-cropping systems, as the agricultural engineering programmes of the other centres get under way and develop needed competences in the field of small farm equipment. It is therefore suggested that, in order to avoid duplication, the leader of IRRI's agricultural engineering programme should extend closer liaison to the other centres, some of which have already received some IRRI prototypes. Of special interest to other centres would be a universal two-wheel tiller and implements, likely to arise from the extension of IRRI's programme to upland crops, equipment for four-wheel tractors, and the axial flow thresher. This latter has already proved capable of handling sorghum and there are reports from India that it is being satisfactorily adapted for wheat. A mutual
exchange of ideas and materials between the centres could be of benefit both to the other centres and to IRRI, and IRRI's ground work could possibly obviate the necessity for expensive basic design work elsewhere. It is not suggested that IRRI should act as a design centre for the network of international research centres as a whole, but simply that the best possible use be made of designs and equipment produced at IRRI which could have application in other centres' programmes.

Links with the University of the Philippines, Los Banos (UPLB)

87. The mission visited the agricultural engineering department of the University of the Philippines, Los Banos, which is adjacent to the IRRI campus. Whilst close and harmonious working relationships exist between the IRRI cropping systems programme and its collaborators in UPLB, there was little apparent cooperation or collaboration between those of the respective engineering programmes. Some degree of duplication of effort was observed (especially regarding paddy drying and threshing equipment), and the mission felt that ways and means should be found to enhance these working relationships. The major emphasis at UPLB was, however, on training in larger scale (rather than village level) milling. Although the facilities, supplied through a UNDP project, are excellent, there appeared to be some attenuation in training programmes and further assistance was being sought in the research and development field. One method by which relationships might be improved (cf. cropping systems programme) could be the provision of subcontractual agreements to assist the UPLB sector of any proposed joint programmes, as well as subcontracting of certain aspects of the milling work for small farmers which might be more appropriately undertaken by UPLB than by IRRI.

Regional Relationships

88. The mission was specifically requested to examine the status of various proposals for technical assistance projects in farm mechanization and post-harvest technology, and the possible role of IRRI in such schemes.

i. Regional mechanization network proposal

89. The mission studied a proposal for an Asian Coordinating Centre for Agricultural Machinery prepared by a joint UNDP/UNIDO/FAO/ESCAP preparatory mission and held discussions with ESCAP on the current status of that proposal. It noted the decision of ESCAP to accept the recommendations of the preparatory mission and to initiate a preparatory assistance project for "The Development of Agricultural Machinery suitable for Use and Production in Asian Countries". The main objectives of this project are to give support to national institutions and industries in the selection and manufacture of appropriate agricultural machinery. The mission believes that IRRI's agricultural engineering programme could well benefit from the establishment of an active and viable programme of this nature. Furthermore such a collaborative network would provide an opportunity for IRRI's already established role to be expanded, and extended beyond its present limits. The mission believes that care should be taken to ensure that there is no duplication of IRRI's efforts and that the emphasis of the regional project should be oriented towards involvement in the development of machinery for upland cultivation, dryland farming and crops other than rice. This would ensure the autonomy of IRRI's programme whilst permitting its maximum contribution as a recognized centre of excellence.

90. The mission noted that siting of the regional coordinating centre had been tentatively proposed in the Philippines although no decision had yet been taken. The mission had reservations about the siting of the project and felt that more thought must be given to this aspect. Whilst welcoming the potential for collaboration between the new coordinating centre and IRRI's agricultural engineering department, it felt there would be some danger of IRRI's programme becoming swamped and its focus diminished by inevitable, but possibly excessive, demands on its staff time and facilities should the centre be sited close to IRRI. In view of the mission's proposal that the technical orientation of the new project should be towards non-rice agriculture, it is suggested that a more appropriate
location could be considered during the preparatory phase of the project. Furthermore, as the project aims at establishing a network, by the strengthening of national institutions, the mission believes that considerable advantages could accrue by the avoidance of too much concentration in one area, as would be the case were the centre to be sited adjacent to IRRI. An additional consideration relates to the fact that the Philippines lie towards the fringe of the area to be served; for ease of communication and relevance to the other needs of the area, it might be placed more centrally.

ii. Activities by Other Agencies on Post-harvest Technology in the Region

91. In the recent past a number of national and international agencies have shown great interest in this field of activity. The present situation is still confused and the mission is not in a position to present clear guidelines. IRRI will, as explained in previous chapters, continue to concentrate its research and development efforts on farm and village level operations. It is prepared to cooperate with other agencies such as FAO - UNDP - IDRC - UPLB, but is reluctant to act as coordinator for more elaborate programmes. The mission fully recognizes IRRI's position in this respect and endorses its policy in this field.

92. The mission also recognizes the need for regional coordination of research, development and training activities in post-harvest technology, to be carried out through a network of national institutes (which may receive assistance through international or bilateral projects).

93. The mission was made aware of a FAO regional project proposal which in principle was endorsed by UNDP. The basic concept of the FAO/UNDP regional project emerged from the national projects carried out over the past decade, and is primarily designed to coordinate research and training activities carried out in the region at national level, mainly in Burma, India, Indonesia, Malaysia, Philippines, Sri Lanka and Thailand. During the preparatory phase of this project, a workshop is planned with the relevant institutes of the aforementioned countries. This project would not overlap with IRRI activities and would in fact be complementary.

94. The mission also examined a proposal by IDRC for a regional post-harvest technology research project, similar in many respects to that of FAO, which was prepared following a regional workshop (held at IRRI) and subsequent study mission. At its ninth meeting the TAC was unable to reach a conclusion regarding the desirability of forwarding a recommendation to the Consultative Group regarding post-harvest technology research, in the face of the diverse proposals made, and requested the mission to examine the situation and present its conclusions and advice.

95. As stated above, the mission fully recognizes a need for the regional coordination of post-harvest technology research, development and training activities in the region. It believes that there is an urgent need for collaboration between donors at the highest level in this field. Much existing introduced technology (e.g., central storage and milling facilities) is lying idle, and highly capitalized technical assistance projects are being under-utilized. The mission was unable to reach a clear consensus regarding the relative merits and demerits of the proposals examined, and believes that there is adequate scope in this field for all potential donors. It therefore supports strongly the suggestion made by the TAC itself that interested donors should be brought together in order to formulate an agreed programme, possibly sub-divided into the fields of research, development and training, or alternatively, on a national or group country basis comprising all activities, and that additional potential collaborators (e.g., the developed countries of ASEAN group and SEAN) be invited to participate. Only in this way, it is believed, will the present confused situation of apparent competition between, and duplication of donors' proposals, be resolved. It is suggested, initially, that the TAC proposal for immediate discussions between FAO, UNDP and IDRC be implemented, with a view to the preparation of an agreed document for consideration by the TAC.
TERMS OF REFERENCE

Introduction

The Consultative Group on International Agricultural Research (CGIAR) has charged its Technical Advisory Committee (TAC) with the conduct of quinquennial reviews of the value and effectiveness of the International Agricultural Research Institutes, Centres and Programmes which derive their financial support from the members of the CGIAR. It was agreed by the TAC at its Eighth Meeting held in August 1974 that the International Rice Research Institute (IRRI), should be the first of the International Centres whose work would be reviewed and evaluated by the TAC. The present Review Mission is being organized in accordance with that decision.

Scope and purpose of the Review

The major objective of such missions has been defined by TAC in agreement with the Directors of the International Centres as follows:

"on behalf of the Consultative Group, to assess the quality and value of the scientific programmes of the Centres in order to assure the Consultative Group members that the operations being funded are being carried out in line with declared policies and to the full international standard expected."

It is hoped that the review will inter alia assist the International Centres themselves in planning their programmes and ensuring the validity of the research priorities recognized by the Boards of the Centres.

Agricultural engineering represents an important component of IRRI central research programme, but the bulk of the cost is currently being funded outside the 'core' budget on a grant from USAID. It is proposed by IRRI to incorporate the machinery development programme into the Institute's 'core' activities in 1975; and the Technical Advisory Committee has been asked to advise the Consultative Group on this at its July meeting. The TAC therefore agreed to undertake a separate review of the agricultural engineering aspects of the programme in advance of the main review mission.

Terms of reference for engineering review team

In pursuance of the objectives defined above and in consultation with the Director and appropriate staff of IRRI, the Mission should pay particular attention to-

(i) the scope, content, and objectives of the present (and planned) programme of research in agricultural engineering at the Institute in relation to (a) the broad mandate of the Institute, and (b) the immediate and longer-term needs of the rice industry globally and in Asia, with particular reference to its relevance to the needs of small farmers, and to national socio-economic goals (employment etc.). The Mission should review both the field mechanisation and post-harvest aspects of the engineering programme and the degree to which these are, or need to be, integrated with each other and with the other work of the Institute;

(ii) the results of past research programmes in agricultural engineering including those to evaluate and test existing equipment for its application to rice production under Asian conditions; and the use to which these results have been (or are planned to be) put, including their impact on the evolution of the Institute's current research programme;
the extent to which it has proved possible to develop effective linkages with the manufacturing sector both at the village and industrial level (a) in the Philippines, (b) in other countries where products of IRRI's research are being introduced (number, type and distribution of machines manufactured; cost effectiveness or other competitive advantages etc.);

the current training and related activities designed to help strengthen national capabilities in agricultural engineering (seminars, workshops, information services etc.);

the adequacy of the resources available or sought, to implement the programme of research and training identified above;

the constraints other than any identified in (v) above which may be hindering the achievement of the Institute's objectives in this field and possible means of reducing or eliminating such constraints;

the nature and effectiveness of work being undertaken outside the 'core' programme, in cooperation with national institutions in the Philippines and elsewhere in Asia. Plans for expanding such work, or extending it to other geographical regions (e.g. to Africa) and possible or existing linkages with other International Centres for this purpose should be taken into consideration;

the need for additional work in agricultural engineering or related subjects which may be considered relevant to IRRI's mandate (a) at the farm level and (b) post harvest;

In respect of this item, particular attention needs to be paid to the UN project for the establishment of an Asian Machinery Centre at Los Baños; and to proposals from IRRI itself, from FAO, and from IDRC (Canada) for additional work on drying, storage and milling.

On the basis of its review the Mission will report to the Chairman of the TAC its views on the overall need for an agricultural engineering programme at IRRI, and whether it should form an integral part of the 'core' programme of the Institute. If it recommends that the programme should be maintained it may suggest any changes in its basic objectives or orientation required to improve the efficiency of its operations or to accelerate the adoption of results. Any expansion considered necessary - for example in post-harvest technology (see viii above) will also be reported; although the Mission may suggest alternative approaches if it sees these as offering the best solution to getting necessary work done.

While the Mission should feel free to make any observations or recommendations it wishes, it must be clearly understood that the Mission cannot commit the sponsoring organization e.g. the CGIAR/TAC.
ANNEX II

ITINERARY AND PERSONS INVOLVED

Sunday, 25th May

Mission assembled at IRRI

Monday, 26th May, IRRI

08.00 - 10.30  Introduction and General Review of IRRI Programme - Discussion  N.C. Brady

10.30 - 12.00  Multiple Cropping and Mechanization - Discussion  R.R. Harwood

12.00 - 13.30  Lunch break

13.30 - 15.00  Mechanization and Soil & Crop Management - Discussion  S.K. de Datta and L.D. Haws

15.00 - 17.00  Background of IRRI Machinery Development Programme  A.U. Khan

Tuesday, 27th May, IRRI Agricultural Engineering Dept.

08.00 - 09.45  Role of Farm Management and Mechanization in Rice Production - Discussion  R. Barker

10.00 - 12.00  Mechanization Systems Research  J.B. Duff

12.00 - 13.15  Lunch break

13.15 - 15.30  Agricultural Machinery Field Demonstrations

15.30 - 18.00  Visit to Kaunlaran Industrial Shop - San Pablo  D.O. Keuther

Wednesday, 28th May (Manila)

07.30  Depart IRRI for all-day trip to Manila

09.30  Visit to Oberly manufacturing company

11.15  Visit to Department of Commerce and Industry, Government of the Philippines  Secretary Paterno

12.30  Lunch break

14.00  Visit to the Department of Agriculture, Government of the Philippines

15.30  Visit to Marsteel Corporation

Thursday, 29th May, Agricultural Engineering Dept.

08.00 - 09.00  IRRI Agricultural Engineering Department  Dr. A.U. Khan & staff

09.00 - 12.00  UPLB Dept. of Agricultural Engineering  Dr. Dante de Padua

13.30 - 16.00  IRRI Agricultural Engineering Dept.

14.00 - 15.00  SEARCA (ENW only)  Dr. Gil Saguiguit

16.00 - 17.30  IRRI Seminar on Aviation in Rice Cultivation

Friday, 30th May, Agricultural Engineering Dept.

08.00 - 12.00  Round-up discussion  Dr. Khan & staff

13.30 - 15.00  Preparation of summary conclusions and recommendations

15.00 - 16.00  Round-up discussion. Cropping Systems  Dr. R. Harwood

16.00 - 20.00  Finalisation of summary conclusions and recommendations
**Saturday, 31 May, IRRI**

08.00 - 10.30  Presentation of Conclusions and Recommendations Discussion  

10.30  Depart IRRI  

16.25  Depart Manila  

18.25  Arrive Bangkok

**Sunday, 1 June, Bangkok, Chiang Mai**

(08.00)  Depart Chiang Mai  

(Kessrs. Doming and Lee)  

(15.00)  Return to Bangkok  

09.00 - 13.00  Preparation of full report outline  

(Kessrs. Pothecary, van Gilist, Webster)  

**Monday, 2 June, Bangkok**

08.00 - 09.00  Visit to FAO Regional Office  

(Pothecary, van Gilist)  

09.00 - 10.30  Visit to ESCAP Headquarters  

10.30 - 12.30  Visit to Engineering Division, Bangkhen  

12.30 - 14.00  Lunch  

(15.40)  Depart Bangkok for Singapore and Indonesia  

(Kessrs. Lee, Pothecary, van Gilist)  

(22.30)  Arrive Djakarta  

14.00 - 16.00  Pramual Kolakit Ltd., Bangkhen  

16.30 - 17.00  Discussion with Rockefeller/IRRI representative  

Rice Department, Bangkhen  

17.00 - 18.00  Return to Bangkok  

18.00 - 19.00  Discussion with FAO Research Adviser, Thailand  

(Kessrs. Downing and Webster)  

**ITINERARY OF KESSRS. POTHECARY AND VAN GILST, INDONESIA**

**Tuesday, 3 June**

08.00 - 09.30  Discussion with representative of IRRI International Programme in Indonesia and Engineer, IRRI/DITNIK project of Directorate of Agricultural Technique.  

09.30 - 11.00  Visit and discussion with P.T. Pupuk Sriwidjaja  

(FUSRI), Djakarta, regarding contract for manufacturing IRRI machines  

**1/ Throughout the field trips in Thailand, Sri Lanka and India the team was accompanied by Dr. Bart Huff of IRRI**
11.00 – 12.30 Visit and discussion, Sales and Distribution Agent Mr. Kris Wiluan for Indonesia for Briggs and Stratton – Contract to manufacture IRRI machines. PT – UNIMAS MOTOR WASTA

12.30 – 13.00 Visit to FAO Country Representative Mr. Denton Thompson

15.30 Departure for Bandung

**Wednesday, 4 June**

09.00 – 10.30 Visit to IKABI Primkopad Bonggasmat II Produksi Mesin Dan Engineering Prototype power tiller Mr. A. Sundoro, Gen. Manager

10.30 – 12.00 Visit to P.T. Purna Sudara (FINDAL) planning to produce IRRI axial flow thresher (at present testing first model). Ir. Juwono

13.00 – 14.00 Discussion on IRRI machinery tested in Indonesia Mr. R. Dadang Tarmana

15.00 Departure for Bogor

**Thursday, 5 June**

09.00 – 11.00 Discussion with IRRI experts - Bogor Cropping Systems – Statistics and Economics J.L. McIntosh, M. Morris

11.00 Departure for Jakarta

12.00 – 14.00 Discussion with FAO Senior Representative to Indonesia Mr. Denton Thompson

16.30 Departure for Bombay

02.00 Arrive Bombay

**ITINERARY OF MESSRS. DOWNING, WEBSTER AND DUFF, THAILAND & SRI LANKA**

**Tuesday, 3 June, Thailand**

08.00 Depart Bangkok for Ayudhaya Accompanied by Messrs. Chak Chakkaphak and Niyom Thuyaprasart

09.00 – 10.30 Visit to J. Charcenchai machine shop, Ayudhaya

10.30 – 11.00 Brief overview of other activities in Ayudhaya

11.00 – 11.30 Return to Bangkok Airport

12.45 Depart for Colombo, via Singapore

16.30 – 22.30 Visit Singapore with Dr. Lee, discussions on report.

23.00 Depart for Colombo

**Wednesday, 4 June, Sri Lanka**

00.15 Arrive Colombo Dr. R.C. Khatter IRRI

08.00 – 10.00 Visit Somasiri Hullers, Nugegoda Mr. M.D.P. Dias

10.00 – 11.00 Visit Nugegoda Medium-Scale Engineering Cooperative Society (NUMEZO) Mr. Deraniyagala

11.00 – 12.00 Visit Colombo Commercial Co. Ltd. Mr. N. Jinasena

12.00 – 13.00 Lunch Mr. R. Jinasena

13.00 – 14.00 Visit Jinasena Ltd., Colombo Messrs. A. Vanadevan, Hulangamuwa & Kathirgamathamby

14.00 – 15.30 Visit Jinasena Ltd., Plant & Foundry, Ekala, Ja.Ela Dr. A. Braid

15.30 – 17.00 Agricultural Implements Project (Dept. of Agriculture) Welisara Mr. Das Gupta

18.00 – 19.00 SAA/FAO Country Representative, & FAO Agricultural Mechanization Expert
**Thursday, 5 June**

10.00
Depart Colombo for Madras

12.00 - 16.30
Madras

20.10
Arrive Bombay

The Mission reassembled in Bombay

**Friday, 6 June, Bombay**

09.00 - 12.00
American Spring and Pressing Works Pvt. Ltd.
Malad, Bombay

12.00 - 14.00
Lunch

14.00 - 15.00
International Tractor Co. of India Ltd.

19.55
Depart Bombay

**Saturday, 7 June, Rome**

04.10
Arrive Rome

**Monday, 9 June - Wednesday 11 June**

TAC Secretariat, FAO Headquarters, Rome

Preparation of Report
VISITS TO GOVERNMENTS AND INDUSTRY

Introduction

1. The visits to institutions and manufacturers cooperating with IRRI in selected countries were of great value in evaluating IRRI's impact in the Region.

2. First of all the Mission wishes to draw attention to the fact that in the Region there are considerable differences in farm mechanization activities. In India, Korea, Philippines and to a lesser extent in Thailand and Pakistan, considerable development in local manufacturing of farm equipment in meeting local demands was an established fact before the IRRI programme started. Especially in these countries industry looks at IRRI's engineering programme as a relatively cheap input towards the improvement of product design and furnishing of new ideas. In these countries the IRRI approach has, in turn, had a major impact on government institutions' approach especially in the establishment of closer links with the smaller manufacturer. In other countries e.g. Indonesia, Sri Lanka and Bangladesh, where mechanization has been neglected or identified only with tractorization, IRRI has contributed towards influencing governments as well as private industries in taking a serious look at farm mechanization in its broader sense as well as to the possibilities of local manufacturing of equipment for the small farmer.

3. The Mission feels that IRRI's programme is of importance not so much in what it has to offer on new designs but more specifically in the approach towards farm mechanization for government institutions as well as the farm mechanization industries. The following is a summary of the visits to government institutions and private manufacturers in India, Indonesia, Sri Lanka, Thailand, and the Philippines, for each country a general introduction on agriculture and development of mechanization is presented.

Background Information

4. India dominates the South Asian subcontinent geographically and its population of some 550 million is larger than that of any other country except China. The country consists of five main environmental zones: (a) the sparsely populated Himalayan mountains which extend along the whole of the northern border; (b) the Indo-Gangetic Plain, a well-watered fertile, heavily populated area; (c) the triangular Deccan Plateau, less densely populated and with limited water resources; (d) the arid Rajasthan Desert on the western boundary, and (e) the humid tropical zones of Kerala (west coast) and Assam (north-east). Rainfall ranges from some 5,000 mm in the north-east to less than 100 mm in the north-west. India has put to use a large proportion of the country's water resources by extending irrigation about 20 percent of the total cultivated lands; but this water is in essence used as a protection against drought rather than as a productive input to obtain maximum yields. The total agricultural production as a whole is still to a large extent influenced by the yearly climatic vagaries.

5. The environmental diversity of the Indian sub-continent permits the growing of a wide range of agricultural crops ranging from temperate through sub-tropical to tropical. Rice, wheat and other cereal crops receive major emphasis and, as high yielding varieties have made considerable impact, more attention is given to diversification of cropping patterns to include fodder crops, grain legumes, horticultural crops and others.

6. India is a large agricultural country with 50,000,000 predominantly small farms (3-5 ha) and a large variety of crops, soils and climatic conditions. The main cereal crops are rice, wheat and barley.
7. In India the local farm machinery industry is relatively important and is manu-
ufacturing with a high "local content". It produces nearly all the machinery for the country.
The biggest sector is the tractor manufacturing industry. The installed capacity is estimated to be about 80,000 per year. The present production however is around 20,000 (mainly manufacturing tractors of around 40-50 hp). Although the demand for 4-wheel tractors is high the industry has not been able to meet the needs. Problems are mainly in the fields of labour, finance and Government pricing policy.

8. With regard to power tillers around 3,000 are manufactured per year although the installed capacity (Mitsubishi and Krishi) is around 48,000 power tillers per year. Generally speaking conditions in India are such that the 2-wheel tractor is less suited than in other South-East Asian countries where rice is a permanent "wet-land" crop and farms are smaller.

9. Most other agricultural equipment is manufactured by a large number of small companies and is estimated at around 1,500 small companies with staffs of 15-70 people.

Research and Development Institutions

10. There are in India about 20 institutions working in the field of agricultural machinery:

1. Agricultural Universities (10 in total)
2. Departments of Agricultural Engineering of the Indian Council for Agricultural Research
3. Tractor Training and Testing Station in Duahni

11. It can be concluded that in India a significant local production of tractors is developing. It has also developed a very important production of diesel and gasoline engines, pumps, sprayers and many components.

VISITS TO INDUSTRY

American Spring and Pressing Ltd., Bombay, India

12. The main products of this plant are a very wide variety of sprayers and dusters for pesticide application. The plant has excellent facilities and produces good quality equipment. A prototype IRRI axial flow thresher has been built and is undergoing major modifications to cylinder and concaves to make it suitable for threshing wheat. This company could produce quality machines in large numbers when the machine is satisfactorily modified for multi-crop threshing.

International Tractor Company of India, Ltd., Bombay, India

13. This company produces 2 models of tractor, a 35 hp and a 45 hp size. They are presently producing 9,000 a year and have just received approval to increase capacity to 20,000 per year. There are 10 other tractor manufacturers in India who have produced over 130,000 tractors since 1969 with production in 1974-75 amounting to 33,000 units. The company also has a factory at Nagpur in which it produces a range of equipment for the tractors. The largest volume of tractors sales is in the north of India in the Punjab. This year it also exported RS. 10 million worth of tractors. The company expressed great interest in the possibility of producing the IRRI axial flow thresher or similar unit for PTO operations with their tractors.
Background Information

14. Indonesian agriculture is a mixture of subsistence farming and export oriented estate production. More than 50 percent of the cultivated land (18 million hectares total cultivated) is devoted to rice on very small holdings. The great majority of the small rice holdings, of which 70 percent are less than 1 hectare, are to be found on the island of Java. Other food crops are grown on each holding (farm yard) as well. The considerable population pressure is specific to Java, Madura, and Bali only. On the other main islands - Borneo, Sumatra and Celebes - land resources consist of several million hectares of reasonably fertile land.

15. The Government has given the highest priority to transmigration of families from Java to other islands. A number of agencies from the U.S.A., Australia, Germany, U.K., Netherlands, as well as the UNDP and World Bank, are involved in this programme. FAO is coordinating these activities: the present ambitious target is to transmigrate 1.5 million people during the next five years. So far 800,000 ha., have been identified as potential areas for development and settlement.

16. Generally speaking the present plans are to settle farmers on 5 Ha. plots, 2-3 Ha. for cash crops and 2-3 Ha. for food crops. It is the intention to establish an infrastructure in these areas taking social and economic aspects into consideration. Work on testing various cropping systems is under way.

Farm Mechanization Potential

17. Problems regarding farm mechanization fall broadly into two main categories:

i. On Java, Madura and Bali with a great number of small holdings producing rice (70 percent being less than 1 Ha).

ii. Other islands - mainly including Sumatra, Celebes and Borneo, with ample land resources for agriculture (upland crop production).

Situation on Java, Madura, Bali

18. On Java, Madura and Bali the main power source for farming is the water buffalo and human labour. The availability of labour is such that even for soil preparation it is sometimes cheaper than animal or mechanical power.

19. Although farm sizes on Java are similar to those in Japan and Taiwan, the absence of a vigorous developing industry absorbing labour means that the introduction of mechanically powered equipment on a large scale will not take place in the foreseeable future.

20. Generally speaking, the farmers of Java, Madura and Bali over the years have been able to intensify their cropping system, diversity and increase their production. The so-called "HEMAS" Government programme contributed to the development considerably. Through the village cooperative (BUD's) it provides the farmer with fertilizer, pesticides, seed and some essential equipment.

21. As expressed in an IRRI report the farming systems as developed over the years on Java and Bali are considered agronomically sound and meet the need of the farmers. It is still questioned whether additional power is required on Java to intensify crop production. This was expressed by Government officials as well as by potential manufacturers who carried out market surveys on Java.
Mechanization potential on other islands - Transmigration programme

22. The many attempts in the past to accelerate transmigration from Java and Madura mainly failed due to the fact that farmers in the transmigration areas received little support. In the past little attention was given to studying the feasibility of developing cropping systems in the areas physically different from Java (mainly upland crops) that would enable the farmer to use all the land allotted to him to maintain the fertility of the soil and control erosion. It is especially in the transmigration areas where the farmers will require additional mechanical power and adequate equipment to farm the 5 Ha. The success of this programme will largely depend upon the possibilities for the farmers to produce enough food for themselves as well as for marketing.

23. The IRRI programme in Indonesia concentrates to a large extent on the development of cropping systems in the transmigration areas. It is felt that it is in this area of activity that agricultural engineers should be especially involved.

Discussion on IRRI Equipment Tested in Indonesia

General remarks

24. Remarks made on the IRRI programme for Agricultural Engineering should be seen in the context of the previous remarks on agricultural development in Indonesia.

25. In general the need for development of farm mechanization systems lays mainly in the transmigration areas of Sumatra, Borneo, Celebes, where upland crops will dominate rice production. It is felt that more emphasis is needed for the identification, development and testing of adequate tools for a small power unit for a number of crops. Soil tillage equipment methods especially deserve more attention. Land reclamation practices in these areas should also be given attention.

26. Manufacturers have difficulty in identifying machinery requirements of the farmers on Java because of the enormous availability of manpower, and in the transmigration areas because of the lack of information.

Single-hopper and multi-hopper seeder for paddy

27. The seeders tested were successful only under conditions with complete water control, completely levelled fields, excellent seedbed preparation and careful attention to the pregermination of the paddy. Transplanting, predominantly carried out by women is the present practice on Java, Bali and Madura, and as there seems to be no time constraint the demand for this type of equipment seems limited. Especially for the transmigration areas, development of simple "dryland" seeders is emphasised.

1/ Cropping systems include multiple cropping and are described by IRRI as follows:

1. Mixed cropping - two or more crops grown simultaneously and intermingled, no row cultivation.
2. Intercropping - two or more crops grown simultaneously in alternate rows on the same land.
3. Intercropping - long term annual or biennial crops interplanted with short-term annual crops during early stages of development.
4. Interplanting - arable crops grown under perennial crops.
5. Relay planting - the maturing annual crops interplanted with seedlings or seeds of the following crop.
6. Sequential planting - planting another crop as soon as the previous crop is harvested.
Fertilizer-insecticide applicators

28. Fertilizer application at present is by hand (broadcasting). The significant increase of efficiency by placing fertilizer in the root zone of the rice plant is attracting the attention of research workers in Indonesia, and trials at farm level are scheduled for the near future.

Weeders

29. Weed control in rice with the aid of the hand-operated rotary weeder is a traditional practice in Indonesia. Herbicides are not being used. Development of mechanical weeder systems for various cropping systems, including mechanically powered weeder (for instance for the Fieldmaster) deserve attention.

Soil tillage

30. The Fieldmaster is equipped with puddling wheels only. Especially in areas where dryland crops are included the need for a wider range of equipment will be essential. Tillage experiments deserve more attention.

Harvesting

31. The IRRI axial flow thresher has been tested with a number of different varieties and with new varieties the thresher works satisfactorily. Major problems occur when threshing traditional longer-strawed varieties especially when freshly cut. Sufficient labour, tradition, and difficult access to the fields are factors which lead to the conclusion for relatively small demand on Java. The demand for the thresher is likely to be mainly in the transmigration areas provided the thresher can be adapted to thresh a variety of crops.

Seed cleaner

32. The rotary seed cleaner has successfully been used at the seed multiplication Centre at Sukamandi. Interest was shown in the recently developed oscillating seed cleaner.

Drying of paddy

33. Drying is at present mainly carried out "along the road" and on concrete floors near the village mills. The small batch type dryer needs more elaborate testing at the village level.

VISITS TO INDUSTRY

F.T. Pupuk Srinidjaja (PUSRI), Palembang

34. PUSRI is an autonomous Government agency responsible for the manufacturing of fertilizer. The fertilizer plant is established in Palembang (Sumatra). At present they are much engaged in expanding their capacity. Workshop facilities are such that the management considers it feasible to take up manufacturing of farm equipment. It has entered into a contract with IRRI to fabricate machinery. At present interest is shown in the thresher. It was mentioned however that the staff of the workshop is at present heavily involved in the expansion of the fertilizer plant and it is planned to cooperate with a blacksmith in Palembang to manufacture the first prototype. It was also mentioned that there is no clear idea at present for which type of equipment there will be a demand.
Sales and Service Agent for Briggs and Stratton for Indonesia - Parent company UNIMAS in Singapore

35. The main activities of the company at present comprises sales and services of Briggs and Stratton engines. The dealer network covers the whole of Indonesia. The main interest of the company in the IRRI machinery is the application of Briggs and Stratton motors. The company will therefore try to generate manufacture of equipment by supplying services to potential local manufacturers. The parent company in Singapore is involved in the adaptation of IRRI machinery (dryer, thresher and power tiller). The company has started a market survey. Main limitation is the income of the very small farmers. The village level farmers' unions (BUD's) may become users of the equipment IRRI is presently offering.

Visit and discussion at PINDAD and IKABI - Bandung

36. Both organizations are part of the military defence system. PINDAD is mainly engaged in manufacturing army equipment while IKABI is the maintenance agency. Both agencies have, over the past years, been engaged in manufacturing agricultural equipment. PINDAD has been manufacturing hand spraying equipment, thresher for rice mills, pedal threshers, rice mills, small batch-type driers.

37. Manufacture of sprayers has so far been the main item (3,000 - 5,000 per year). The equipment is distributed mainly through the Government's EIMAS programmes.

38. IKABI at present is planned to be reorganized as a Government agency (PERUM) for manufacturing and marketing of equipment. This agency is also involved in a market survey and has entered into an IRRI contract for manufacturing and testing of the power-tiller and thresher. It was felt that more emphasis should be given to equipment for soil tillage which would include equipment for upland crops. The thresher should also be developed as a multi-purpose thresher.

Post-harvest technology

39. The mission was made aware of an FAO project aiming at Strengthening of the Rice Processing Centre, Tambun, for prevention of losses and waste in National Rice Stockpile Operations, which may be of interest as complementing the programme IRRI is developing in the region. It is part of BULOG, an autonomous Government agency responsible for carrying out the grain management and price stabilization programmes of the Government.

40. The main functions are:
   1. To establish a fair price to the farmers through guaranteed minimum price schemes.
   2. Planning and operating national buffer stocks of rice.
   3. Direct procurement of rice/paddy to support producers prices.
   5. Deployment and distribution of supplies from buffer stocks.
   6. Supply of rice to Government service and others.

41. The immediate objective is to undertake preventive and curative measures for reduction of losses and waste occurring in all stages of national stockpile operations.
SRI LANKA

Background Information

42. Sri Lanka can be conveniently divided into two distinct zones from the climatic, agricultural and economic viewpoints. These zones are called the "wet" and the "dry" zones; they are uneven in size, the wet zone representing one-third of the total area of the country. This zone is heavily populated, contains little uncultivated land and is much more developed than the dry zone. Farming activities are divided into the estate sector, which provides the three main export crops (coconut, tea, rubber) and the small holders sector mainly growing rice. Ninety percent of the holdings in the rice-growing area are less than 1 hectare in size. Special efforts are being made for new intensively cultivated settlements on formerly privately owned land.

43. The dependency of the country on three major export crops has led successive governments to encourage agricultural diversification. In the irrigable areas of the dry zone rice and sugar cane are grown commodities which so far have been responsible for the major import bills of the country. Self-sufficiency in rice may be expected towards the end of the present decade. Other attempts at diversifying are taking place relatively slowly; livestock, timber and some minor export crops such as chillies, onions, cocoa, coffee, cloves, pepper, nutmegs, cashew, etc.

44. Scarcity of foreign exchange as well as minerals and other resources is an important constraint to development in Sri Lanka. The country's economy is therefore predominantly agricultural. Rice is the main food crop. Tea, rubber and coconut account for the largest part of foreign exchange earnings.

45. The relatively high rate of population growth, the scarcity of foreign exchange, together with land shortage, have led to considerable employment problems. Agriculture has to absorb much of the additional labour force each year.

46. Little effort has been made in recent years to help farmers to develop an appropriate level of mechanization. An important reason for the relatively little concern shown for farm mechanization is given in a report of a country study on labour management. In very general terms the report mentions that farm mechanization is harmful to the employment situation without going into the details of it and its relevance to the need of increased agricultural production.

47. Around 1.1 million buffaloes and 1.9 million cattle are the most important power source. At present there are about 14,000 4 wheel tractors (40 hp) in use in the country, mainly employed for soil tillage and transport. Importation is very much restricted and it is difficult to keep the existing tractors in operation. A review of this policy is felt necessary.

VISITS TO INDUSTRY

Somasiri Hullers and Nugegoda Cooperative, Colombo

48. This factory is the base shop for the main cooperative development programme for producing small machines for both upland and lowland conditions. Associated with the main private enterprise factory are 10 smaller government sponsored cooperative assembly shops which are supplied component parts by a number of small job shops making only 1 or 2 components each. The main factory is well equipped with 10 lathes, welding equipment and a unique casting unit. The small assembly shops have 1 lathe, 1 drill press, welding facilities and

*"Dry zone" must be understood in a relative way; total yearly rainfall is 1500 mm. with severe months, each below 50 mm; as against a wet zone with a rather fairly well distributed rainfall of 2500 mm.
general tools. The small power tiller is the principle unit being produced at present. The main problem is obtaining satisfactory parts from the main small job shops. The factory is presently developing an engine for a 4 wheel tractor.

Colombo Commercial Engineering, Ltd., Colombo

49. This is a large manufacturer specializing in machinery for processing of tea and rubber and for heating and ventilating. They have built, under sub-contract from the national testing institute, an IRRI axial flow thresher. Very good capability in sheet metal and workshops but are not interested in manufacturing unless a reasonable demand of 500 units per year develops. Company is limited in expansion by government regulations and is unable to accept a licensing contract also due to government policy. Need support and interest of the Ministry of Agriculture for allocation of materials and import of special parts.

Jinasena, Ltd., Colombo and Ja-Ela, Sri Lanka

50. This is an excellent operation, clean, well-organized, well managed with exceptionally good production. Main products are pumps and electric motors. They are actually evaluating the possibility of manufacturing 2 wheel tractors, threshers and other implements and have developed a 5 hp engine. They have an excellent foundry for any casting work. The company is managed by three brothers, all engineers with advanced work and experience in U.K. and U.S.A. They suggest that IRRI needs to work on advanced technology and only develop prototype machines. IRRI should work through a governmental organization such as Department of Agriculture or Industry. This company could make quality machines in large numbers provided support from government was obtained for the import of essential parts and machine tools.

Agricultural Implements Project, Welisara

51. The basic objective of this workshop of the Department of Agriculture was to develop and sell machines to the farmer. However there has been very low productivity with an excess of sophisticated machine tools supplied through Australian technical assistance. Machines seem to be developed on an ad hoc basis with a very high subsidy making it difficult for local industry to compete. Storage bins with slotted floors and a copy of a Japanese single row weeder, and a power tiller, were being produced. The unit seemed to be in isolation from local industry with very little awareness of market potential for the units being built.

THAILAND

Background Information

52. Thailand has predominantly an agricultural economy with expansion to other sectors. The country is naturally divided into four regions, which are also relevant to the development of appropriate mechanization systems: the northern region covers the mountainous areas and is heavily forested; the average rainfall is 800 - 1200 mm. Crops are rice, tobacco, groundnuts, soybeans, and fruit trees. Double cropping is practised. The central region is mainly the rice producing area. A "double cropping campaign" is making good progress. Average rainfall is 800-1200 mm. The north-east region, through which the Mekong River passes, is flooded during the monsoon season and very dry during the summer period. This region is considered especially suitable for livestock raising. The average rainfall is 800-1200 mm. The southern region has the highest level of rainfall in the range of 2000-4000 mm. The topography is from rolling to mountainous. Rubber and coconut are popular in this region.
53. Thailand's total farm holding land is around 13 million hectares of which over 7 million Ha. are paddy, 0.8 million natural rubber, 1.2 million Ha. for fruit crops, 2.2 million Ha. for upland crops, 1 million Ha. woodland, and 1 million Ha unclassified.

54. Being faced with a rapidly changing agricultural situation, the Government has given very high priority to changing traditional agriculture by introducing new technology and farming systems as well as stimulating new processing and marketing techniques. The main power source at the farm is still the draught animal (5 million). In the field of farm mechanization local production of small tractors, threshers, and hand tools, is becoming popular. Some 4,000 power tillers of 7-9 hp have been manufactured locally over the past years by some fifty manufacturers. These are considerably cheaper than imported two-wheel tractors. About 30,000 4 wheel tractors (50-75 hp) are in operation, mostly owned by farmer contractors or by larger farmers. Tractors are mainly used for primary tillage, levelling and transport. 4 wheel tractors in rice growing areas with large enough fields, are more popular than 2 wheel tractors. Nearly all rice harvesting is done by sickle, and threshing by hand. At present the IRRI axial flow thresher and the IRRI developed power-tiller are being tested. However, it is felt that refinement of the locally designed two-wheeled tractors requires more attention from IRRI's engineers for further improvement.

55. With regard to rice processing, in the recent past the large capacity mills which were concentrated in the areas of Bangkok, Dhomburi and Ayudhaya have been closed mainly because of the high cost of capital and large capital provisions which were required for their paddy procurement schemes. As a result a multitude of small and medium capacity mills have been established in the rice producing areas and the local manufacture of medium capacity rice processing machinery has been undertaken in the country.

**INDUSTRY VISITS**

Amsart Company, Ltd., Chiangmai

56. A small open air shop operation manufacturing the small IRRI power tiller. Fourteen have been produced with ten more on order. These units are replacing the Honda walking tractor of similar size that the owner has been distributing but at about 3 times the price of the locally manufactured units. The company also makes a tiller, harrow and a small plough on a modified design of the Japanese unit. The IRRI plough was unsuitable for the dry soil conditions in the area. Production could be increased in present facilities, and the owner would like to incorporate steering clutches into the unit. The owner is a well-qualified engineer and implied he would like to see some degree of standardization on specifications for machines. There is apparently an increasing demand for power tillers as buffalo are being sold illegally for meat, in view of its present high price, as well as the cost of feeding the buffalo during the year.

J. Chareonchai, Ayudhaya

57. A medium-sized company expanding very rapidly, building power tillers at the rate of 2 per day and 4 wheel tractors to its own design at the rate of 1 per day. The IRRI power tiller transmission and drive wheels have been completely redesigned. A small assembly line system has been set up for producing the 4 wheel tractor. The frame is fabricated from sheet metal and various components are incorporated directly into the frame. It uses a 12 hp diesel engine, has a single speed transmission and a simple 3 point hitch for equipment. Steering mechanisms are obtained from wrecked cars. A very industrious young owner with quite good facilities. A number of other small shops in the area are also producing small locally developed power tillers.

Pramual Kolakit, Ltd., Bangkok

58. A small to medium size company which produces a variety of special agricultural machines, such as driers, land levellers and more recently the IRRI axial flow thresher. Facilities and equipment are quite good although at present the company is only producing a few threshers on a firm order basis. The thresher is being modified to better meet the Thailand crop conditions. Could increase production quite appreciably.
Agricultural Engineering Department, Ministry of Agriculture, Bangkok

59. This department has quite extensive machine shops as well as fabrication and research shop facilities. Early development work was carried out on small power tillers as well as on 4 wheel small tractors. There is quite good contact and relations with the local shops and manufacturers; of these there are at least 100 shops and more than 25 small manufacturers, producing at least 3,000 small tractors annually. This department, which is quite capable of doing design and development work, is an excellent link in the IRRI contract programme. As in the Philippines, however, there is need to better develop extension programmes to the farm level.

PHILIPPINES

Background Information

60. Topographically 35% of the land area in the Philippines, consisting of some 7,000 large and small islands, is low-lying coastal land suited to wet-landpaddy, and 65% is uplands suitable for "dry" paddy and other crops. An average rainfall of about 2,360 mm. (ranging between 1,250 and 3,750 mm.) is received from the north-east and south-west monsoons. In spite of the heavy yearly rainfall over the entire country, agriculture in many parts of the Republic of the Philippines has to depend on irrigation. This is due mainly to the uneven distribution of precipitation over the various seasons. In parts of the country, even during the rainy season, supplementary irrigation is needed for the main crop production, and no second crop is possible without irrigation.

61. As a result of the division into many islands irrigation development tends to be in the form of many relatively small projects. Only a few larger river basins exist and these are characterized by steep mountain areas where rain is intensive and rapid, commanding flat valley lands subject to flooding and prolonged water-logging. Most of these valley lands need drainage and flood control projects for the monsoon months as well as supplementary irrigation projects for the drier months. With the exception of the Cagayan Valley, Philippine soils are not very fertile.

62. About 78% of the total farms have less than 4 hectares of land. The highest number of farms (around 50%) are engaged in rice culture, with coconut and maize coming next. Other important crops are tobacco, vegetables, sugar cane, root crops (cassava and sweet potatoes), fruits and nuts (bananas, citrus, pineapples, mango, etc.) and coffee.

63. Rice and maize are the main cereals and form the staple diet of 75% and 27% respectively of the population. The productivity of irrigated rice has appreciably improved as a result of the high-yielding varieties developed by IRRI. Upland rice still needs improvement, especially in production technology. Maize hybrids and synthetics have been developed locally with assistance from outside but have not made a significant impact.

64. The climatic conditions are suited to multiple cropping and more than one crop on the same land is produced on some 34% of the farms. However, practices need to be rationalized, taking into account the crop productivity, profitability, use of inputs and cultural practices.

65. Until recently mechanization received limited attention. For about 70% of the cultivated area around 2 million carabaos (buffaloes) are the only power source (1 carabao for 2-3 Ha). Prices of carabaos are increasing. The locally built, adapted Landmaster 2-wheel power tiller, promoted by IRRI is gaining popularity over the more expensive imported tillers (total 2-wheel tractor population is about 20,000).

66. At present around 15,000 4-wheeled tractors (50-75 hp) are in use (large farms, sugar cane estates, tractor hire services). Development of appropriate tillage implements is required. Apart from IRRI activities which have had an influence on the overall trend towards mechanization, the Agricultural Engineering Department of the University of Los Baños is the main institution in the Philippines engaged in agricultural mechanization.
The Mission was surprised to learn that no contact existed so far between the Mechanization Unit of the Ministry of Agriculture (Bureau of Extension) and IRRI.

INDUSTRY VISITS

Kaunlaron Industrial - Hop - San Pablo

68. A small single machine shop with common basic tools building the IRRI thresher, fully in line with IRRI design. The owner is quite an ingenious young man planning to expand facilities to increase production. Will require continued IRRI engineering and testing support but has good potential for development.

Oberly Manufacturing Co., Manila

69. A small to medium sized company, well established, manufacturing the power tiller and axial flow thresher as well as small industrial equipment such as cement mixers. Although conditions are crowded the operation is quite well organized. The company has the ability and facility to alter designs to meet its own manufacturing techniques and also to make improvements on machines to suit local conditions. This company could increase production quite appreciably.

Marsteel Corporation, Manila

70. A large steel manufacturer and fabricator. The company is presently producing power tillers, adapted by IRRI (Landmaster two wheel tractor) at a rate of 2000 per year along with ancillary equipment. It has a large foundry and has modified the tiller to case the transmission, and is planning to incorporate steering clutches in the new model. It does fairly extensive testing of machines but has requested separate tests by IRRI primarily for advertisement purposes. This company is very capable of manufacturing machines from design drawing or prototype units and could produce larger tillers, 4 wheel tractors and axial flow threshers.
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