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**AGENCY FOR INTERNATIONAL DEVELOPMENT**

**SPRING REVIEW  
OF  
THE NEW CEREAL VARIETIES**

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**MAY 13 - 19, 1969**

**IMPLICATIONS FOR A.I.D.**

SPRING REVIEW OF THE NEW CEREAL VARIETIES  
IMPLICATIONS FOR A.I.D.

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## INTRODUCTION

The Review of the high-yielding cereal varieties was directed at two questions--

1. What lessons can be learned for improving specific A.I.D. activities in agriculture?

2. What conclusions can be drawn concerning the relative emphasis among activities in A.I.D.'s future agricultural strategy?

The present paper attempts to summarize the conclusions of the Review relevant to these questions. The sections which follow contain a general statement of proposed A.I.D. agricultural strategy (Section I) and the findings and recommendations on the major topics covered by the conference (Sections II - VII). For each of the topics covered, the essential background and agreed facts are sketched under the heading FINDINGS; a second part states IMPLICATIONS FOR A.I.D..

Although the Review focused on the high-yielding varieties (HYV) of rice, wheat, and corn, the discussion was wide-ranging and frequently extended into general problems of agricultural development. Moreover, some of the matters discussed involved sensitive political issues for the recipient countries. No material is excluded from this summary because of either of these considerations.

To facilitate consideration of the document, the implications for A.I.D. which have the most immediate significance either for operations or for prompt study are marked by an asterisk.

## I. SUMMARY AND OVERVIEW

1. The notable success in increased grain production in the past couple of years demonstrates what can be accomplished in LDC agriculture. Agriculture continues to merit top priority in most developing countries. The successes in foodgrains, however, call for some shift in emphasis in A.I.D.'s agricultural programs.

2. The "agricultural revolution" has been concentrated essentially in spring wheat and rice, principally in the countries of East and South Asia, and confined almost entirely to areas with ample water supply. Without minimizing in any way an accomplishment which has completely transformed the food prospects of most of the important food deficit countries, A.I.D. must take account of these facts, and of the further fact that even in the countries most benefited, the "revolution" has directly touched only a minority of the farming population. Nevertheless, in breaking the mold of traditional agriculture and demonstrating the results that can follow the introduction of new technology, it has opened the way to further change. A.I.D. must seek to capitalize on the new opportunities for agricultural growth which now exist.

3. Experience with the introduction and diffusion of the new cereal varieties has demonstrated that constraints on agricultural growth are fewer and more readily overcome than previously assumed. This experience indicates that assuming a minimum basic infrastructure the essentials for a marked acceleration in agricultural growth are: a) a new technology which offers the possibility of a significant increase in profits (i.e., reductions in costs per unit of output), b) the capacity with or without outside assistance to adapt this technology to local conditions, c) commitment to a campaign of expanded production at

top levels of the government, d) a cadre of skilled personnel in the agricultural sector which, either inside or outside existing institutions, can be aligned in a campaign structure. Most of these elements may be present in some degree in a given country with little effect on production. In this case, supplying or strengthening the deficient component(s) may produce a sharp rise in output.

4. The Review considered a range of topics - price policy, management systems, institutions, physical inputs, research, and emerging problems - related to the introduction and diffusion of the new cereal varieties. The findings on each of these topics, and their implication for A.I.D., are treated in the following Sections of this paper.

5. Summing up the state of affairs in the spring of 1969, it can be said that agricultural growth in the most populous of the LDCs has reached the point where famine is no longer an imminent threat; where in some countries self-sufficiency in cereals production is already in sight; and where a number of new adjustments will be called for.

6. In considering the problems of the future, it is desirable to begin with the lessons learned from experience with the HYVs. A few basic points emerge as central. These are summarized below:

a. The ability of a well-conducted crop campaign, based on a new and productive technology, to activate important parts of the agricultural sector, and to mobilize the public and private support necessary to its success.

b. The increasing need for wise government policy, as cereals campaigns approach their goals. The HYVs seemed to provide a providential means for escaping the ominous threat of famine and they were seized on eagerly, and utilized without much advance planning. The problems of the future will require more careful study.

c. The need for a continuing flow of technological innovations, produced by research.

d. The need for an expanding body of trained manpower, on which effective policy planning, research and institutional operations will depend.

e. The need for institutions, capable of helping the disadvantaged farmers, who, for want of knowledge, good land, water or financial resources, are unable to respond quickly to new technologies.

These points are developed somewhat more fully in the paragraphs which follow:

7. In almost all countries considered, the HYV rice and wheat proved to be a powerful innovative force which compelled a change in traditional agriculture. They brought new life to moribund institutions - co-operative, private enterprise and governmental - and stimulated the development of ad hoc arrangements where existing institutions were unable to meet felt needs. The single crop campaign has proved a singularly effective way to "get agriculture moving." The success of these campaigns suggests the desirability when the opportunity and basic requisites are present, of a country focusing efforts on a specific sector of the agricultural economy.

8. The HWP is an effective way to introduce an element of dynamism in the agricultural sector. Once this element is present, it begins to generate new problems, and makes even more urgent the development of a coherent strategy for rural development, geared to the country's own requirements and potential. Few LDCs have such a strategy, or, indeed, are capable of producing one. For this type of planning requires competent agricultural economists, and such personnel is in short supply among LDCs. A.I.D. itself is inadequately staffed in this area, and most Missions are unable to provide first-class planning assistance in the agricultural sector. The Agency needs to strengthen its own competence in this field and to make better use of the skills of the U.S. universities and other institutions to provide aid to countries which need and want it. The ultimate objective, of course, must be to strengthen the competence of the LDC to do its own agricultural planning.

9. Recent agricultural growth in the LDCs covered in this review has been generated by new and profitable technologies of cereals production. These technologies were the product of a chain of scientific research: the beginnings were in the institutions and the scientific techniques perfected in the developed countries; the critical transformations occurred in two international research institutes which mobilized interdisciplinary staffs of high competence, assembled banks of genetic materials, and used advanced techniques to produce varieties suitable to the tropics and sub-tropics;

the final phase was the testing and adapting of these new varieties under specific local conditions in the individual LDCs. Continuing progress in LDC agriculture will require a continuing flow of technological innovations, much of which, it may be assumed, will be developed through <sup>similar</sup> processes. A.I.D. needs a clearer overview of the research needs of the developing countries, of the various institutions which are now helping, or could help, to meet these needs. It also needs a clearer concept of the kind of system which will most effectively discharge the dual task of furnishing research products needed by the LDCs in the near term, and strengthening the capacity of the LDCs to do the job for themselves.

10. The performance of the many skilled functions needed for further agricultural development will require an expanding base of skilled manpower in the LDCs. As experience with the new cereal varieties demonstrates, some of the technology can be imported, and the skills essential to a single crop campaign can be developed by overseas training. Ultimately, however, the success of A.I.D.'s programs in the agricultural sector will depend on the degree to which they produce within the LDCs the capability to organize, staff, and administer their own institutions.

11. The Review revealed that with the powerful stimulus of the new cereal varieties, it was possible to improvise a structure to perform the functions essential to their introduction and diffusion. It cannot be assumed that this pattern will be repeated when the more complex second generation problems demand attention. The need for an institutional structure, which includes at least rural education, extension, credit and marketing, is foreseen.

12. Proposals for A.I.D. programs made in this paper of course assume that LDC Governments and important elements of the population want agricultural growth and the improvement of rural life. With such a Government and people to cooperate with, it should be possible for A.I.D., working with other aid-giving countries and institutions, to do much to accelerate the agricultural revolution, and to extend its benefits to larger parts of the population. The capacity to produce technological innovations exists; the techniques for successful crop campaigns have been mastered; means for vitalizing moribund agricultural institutions and enlisting farmer participation in co-operative enterprises have been found. With these assets, Governments can move to a position where it becomes feasible to adopt policies which expand employment, strengthen rural infrastructure, benefit increasing number of farmers, and contribute to overall economic growth. This is the potential of the green revolution; A.I.D.'s objective in the period ahead must be to help the LDCs realize it.

## II. PRICE POLICY

### A. Findings

The HYV experience has revealed a number of the characteristics of farmer response to prices, risk and certainty. That the so-called traditional farmer's presumed high aversion to risk can be overcome by high profitability, has been amply and even dramatically demonstrated.

The technological quantum jump in profitability, under suitable conditions, was the most significant factor in the adoption and diffusion of the new seeds. The differences between wheat (on irrigated or in assured rainfall areas) and rice illustrate this point. The differential success with the new rices in favorable as contrasted with less favorable areas does also. Conditions of relative cereal scarcity in most of the countries considered reinforced the technological shift in profitability, and provided further assurance of high market prices.

Governments, often on A.I.D. urging or with A.I.D. acquiescence, adopted other measures to influence relative profitability. By and large, these direct governmental price interventions--input subsidization and output price support--have been less significant than the basic profitability of new seeds in the diffusion of HYV's. That is, rapid adoption of new responsive varieties has occurred both with and without input subsidies, and under varying types and amounts of output price support.

Although the record indicates that input subsidies (on fertilizer, pesticides, credit, water, electricity) were widely used, they were generally thought to be undesirable by participants in the Review.

Support for input subsidization was largely confined to early subsidies for fertilizer for two limited purposes: to accelerate the initial adoption of new varieties or practices and to hasten the reaching of an economic scale of production and distribution from new indigenous fertilizer plants. Removal of such temporary subsidies was strongly advocated as soon as the initial purposes were served and before political pressures for their maintenance became too strong. The only justification suggested for continuation of input subsidies was that they might be used to provide preferential treatment for low income or disadvantaged farmers if the administrative problems of differential programming could be surmounted.

The record of experience with output price support is less clear as are the conclusions to be adduced from it. There was recognition that high, permanent output price supports might, while increasing production of the supported crop, merely shift acreage or inputs from other crops, not necessarily producing advantage or resulting in an increase in total agricultural output or income. It was also recognized that continuing output price supports above world market prices were undesirable.

A strong case was made that output price supports which might have undesirable side effects when used as an incentive for one or several crops, could provide desirable insurance against the risk of a deep price drop consequent on a sharp rise in production. (There was not much analysis in the crop papers, nor discussion at the Review, of the corollary role of stocks acquired under price support programs when production was high as a buffer against subsequent low production).

The use of output price supports for stabilization purposes was recognized as a valid and probably necessary way to avoid wide uncertainty regarding future market prices, thus eliminating or tempering one of the major risks the farm entrepreneur faces. While majority opinion supported this view and its concomitant moderate ("not high") price support policy, there was no consensus on whether the support price needed to be established before planting (as A.I.D. has usually espoused for "incentive" purposes) or merely before harvest.

The trade-offs are: farmer uncertainty of harvest prices if support prices are not announced early, versus allowance for "some" decline in market prices if a good yield is secured. The advantages of lessening farmer uncertainty are obvious. The advantages of permitting a moderate decline in market prices are: avoidance of undue burden on the public budget and the allowance for controlled secular declines in price if productivity continues to rise. One country crop experience (India-wheat) demonstrates an effort to do both; a low support price (still profitable with HYVs) was announced pre-planting, and a higher procurement price--supporting the market--has been announced just before harvest.

While price stabilization policies were generally considered necessary, and "incentive" prices possibly justified in some cases and for limited periods, it was recognized that any system of price support involves an administrative burden. It was further recognized that less

developed countries characteristically lack highly developed administrative systems.

B. Implications for A.I.D.

The powerful consequences of technological advance on farmer incentives, and the implications for research are discussed in VI. below. Other guidance for A.I.D. which emerged is that:

1. A.I.D. should not in general sponsor or support input subsidies except where they are clearly needed as inducements and are clearly temporary, or (perhaps) if they can be so structured as to have a positive effect on disadvantaged farmers or areas.

2. A.I.D. should in general advise against high, continuing output price supports, except where their allocative effects (shifts in acreage or in input use) have been analyzed and found clearly desirable, and the administrative problem tolerable.

3. A.I.D. should sponsor the development of tailored price support policies and organizations which will provide advance assurance (either by advance announcement or by earned confidence in governmental policies) against sharp price drops, while permitting relatively smooth secular price adjustments in tandem with productivity changes.

4. A.I.D., clearly, will need to take account of the administrative competence of the Government in considering the practical measures the country concerned should be advised to adopt to give effect to these objectives.

5. A.I.D. must increase its in-house capability and the outside competence available to it on contract to analyze the complex of economic, political, and administrative factors involved in the above recommendations so that the Agency's ability to advise, correctly and persuasively, is enhanced.

### III. MANAGEMENT SYSTEMS

#### A. Findings

All the HYV countries covered in the Review mobilized exceptional teams of men and institutions to carry out crop campaigns. In India and Pakistan, two or more crop campaigns were organized without significant A.I.D. administrative participation and carried on simultaneously. In Turkey, Vietnam, and the Philippines single crop campaigns were designed and implemented with A.I.D. assistance. The activating force behind all of these campaigns was a firm resolve by the Government to clear traditional bureaucratic hurdles and make the necessary administrative and financial commitment to reach the target. The Missions report that such support was essential to successful propagation of the HYV programs. It is noteworthy that wherever this support from top Government leaders was provided, its effects were strong and positive. Further, political benefits to the LDC Government frequently accompanied the increased harvest.

Most of these crop campaigns had some quantitative goals--total production to be achieved or total acreage to be covered. They all focused on relatively limited areas of high potential productivity. They all made an effort to provide individual farmers with the information necessary to grow the crop successfully. There was, in all cases, an adequate incentive to the farmer--in terms of the balance of input/output prices--to energize him to participate actively in the campaign. Where these elements were present, an extraordinarily rapid diffusion of the new varieties took place.

In at least two countries--Turkey and Vietnam--a more systematic effort was made to schedule the provision of key inputs of technical information and material on a precisely calculated time-phased basis. In Vietnam a full-fledged PERT system was developed during the second crop season to provide better control over the IR-8 rice production program. USAID officials insist that these advanced programming and implementation systems improved the Government's control over the crop campaign and contributed to its success. Their arguments are persuasive, although there is no quantitative means to measure the contribution and seemingly comparable successes occurred in other countries employing less elaborate techniques.

Any system, of course, must be built on the already existing institutional structure, and should reflect the judgment of those who know the strengths and weaknesses of the institutions involved. The effective implementation of crop campaigns and advanced scheduling systems would appear to depend upon the availability of a number of factors which some of the less advanced countries do not possess. The prerequisites include (1) a reserve of skilled personnel to draw on, (2) an institutional base sufficiently articulated yet flexible to be galvanized into a national campaign, (3) input/output price relationships which made adoption of the new crop technology an attractive proposition for the farmer, including administrative action to minimize the risk of price declines resulting from a rapid increase in output and (4) a firm commitment to the campaign at the highest level of government. Where these prerequisites are satisfied, A.I.D. has demonstrated the ability

to effectively supply the missing management technology to support the initial takeoff. In these circumstances, crop campaigns may be a highly useful instrument and serve to energize the entire agricultural sector. But the ultimate decision to institute such a campaign depends of course on the economic argument for rapid boosts in production of the target crop.

B. Implications for A.I.D.

1. The principles and techniques of crop campaigns should be more systematically studied by A.I.D., and the methodologies suitable to countries of different levels of administrative competence should be defined. Additional personnel should be trained in these techniques, and the provision of consultants may be called for. Professional training in agriculture is not indispensable for the top leadership in the effective management of crop campaigns.
2. A.I.D. should encourage crop production campaigns in food deficit countries where the necessary pre-conditions described above exist, where rapid increases in the single crop would have high returns and would support the general development program, and particularly where such a campaign seems likely to energize other parts of the agricultural sector.
3. A.I.D. should encourage the LDC to adopt the advanced programming systems only if the Government has the degree of administrative sophistication, statistical coverage and trained analytical strength to make them work. A judgment must also be made concerning where the marginal returns of increasing the sophistication of the system cease to justify the marginal costs involved. Many countries are markedly deficient in the resources they can mobilize for such an undertaking and large teams of

A.I.D. managerial talent to perform these services is not a recommended alternative. However, this approach can be encouraged where it seems possible that necessary improvements could be made by the training of local personnel and the provision of a reasonable amount of technical assistance. The decision as to whether to initiate a crop campaign should be made on the basis of the Mission's assessment of the will of the Government and the probable ratio of benefits to costs.

4. The direct involvement of an A.I.D. Mission in a crop production campaign may require some regrouping of tasks and reallocation of Mission personnel. There must be arrangements which produce quick decisions and mobilize forces where they are most needed to break bottlenecks and contribute to the smooth operation of the system.

5. The extent to which Governments will be required to discharge functions in the crop campaign will depend on the strength and effectiveness of the private sector. In most cases, it is desirable that the private sector perform a wide range of tasks, from the distribution of fertilizer and seeds to the marketing of crops, for the more such services are provided by the private sector, the lighter will be the burden on Government administration. The role of Government in a country where the private sector is operating well can be largely confined to providing information, monitoring, and performing compensatory functions--i.e., intervening when the job is not satisfactorily performed by the private sector. An almost universal problem is the cost of these services. The services may be more efficiently performed by private enterprise but the provision of the essential infrastructure for

seed and fertilizer distribution and for marketing is for the most part a responsibility of Government. The existence of a responsive private sector is of course essential to this division of labor, but in most countries Governments tend to underestimate their private sector's capacity for action. A.I.D. needs to work harder on opportunities for private participation and on encouraging it. And A.I.D. needs to know more about the costs of distribution and marketing, and how to reduce them.

#### IV. INSTITUTIONS

##### A. Findings

No one group of Government institutions proved to be indispensable to the successful introduction of the high-yielding varieties in all countries considered. The availability of well-trained technicians, and of a flexible and popular rural institutional network capable of alignment in a campaign structure, were essential, as were a capacity for adaptive research and a procurement authority. Extension played a decisive role in a few countries: elsewhere diffusion of practices proceeded rapidly regardless of the quality of the extension service. The lack of institutionalized credit doesn't appear to have slowed the early diffusion process, especially in the wheat areas. Finally, in most places, co-ops and community development had little observable effect. Certain functions, such as the dissemination of knowledge, the distribution of seeds and fertilizer, etc., had to be performed, but on balance the precise contribution to the discharge of these functions of formal and typically laboriously created institutionalized services is unimpressive.

It is probable that the HYVP<sup>†</sup> is an inadequate measure of institutional success. It is also probable that the contribution of traditional institutions will become increasingly significant with elapsed time, both in expanding the HYVP and in dealing with second and third generation problems. The evidence seems to indicate, however, that, given a significant, tested, technical breakthrough to exploit, and an effective product demand, a successful production campaign can be mounted with less explicit attention to formal institutional underpinning than heretofore thought necessary.

Distinguishing among three types of institutional management

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<sup>†</sup>High-yielding Variety Program

helps to organize another set of lessons of the HYV experience. There are (1) the traditional government institutions, including rural and professional education, research, extension and credit; (2) private enterprise operating in the agricultural service sector -- e.g., ESSO, the Kenya Seed Company and other fertilizer, machinery, insecticide and seed producers and distributors; (3) farmers' co-operative institutions, which make collective decisions for farmers at the village (machine pools, fertilizer distribution) or multi-village (water supply, drainage, pest control) levels. Private enterprise offers a frequently unrealized potential for reducing the burden on governmental services. Where profits are clearly indicated, as they have been in the HYV areas, private enterprise has been quick to exploit opportunities, provided the climate for individual initiative has been favorable. Similarly, co-operative institutions have mushroomed spontaneously in certain HYV areas, once their functional utility was demonstrated. Both private enterprise and co-ops offer alternatives to government service, but of the two the former seems to be more readily responsive to deliberate government inducements and can be expected to play a leading role in diffusing future technological breakthroughs. Everywhere, however, the increased services required by the HYV's are stimulating the creation of new institutions as well as the revitalization of old ones.

B. Implications for A.I.D.

Some caution is advisable in applying the lessons learned in HYV campaigns to agricultural development in general. The results obtained were abnormally profitable and the urge to share in the profits an unusually powerful stimulus. Although the contribution (or lack of contribution) of individual institutions to HYV campaigns should certainly be taken into account in planning programs to sup-

port agricultural institutions it may not be a fully satisfactory indication of their worth in other situations. On the basis of experience with crop production campaigns, it is not possible to conclude that the building of any particular set of institutions will automatically result in increased agricultural production. There are indications, however, that the availability of a responsive institutional base is probably essential for the fullest exploitation of any technological breakthrough.

1. Pending the development of further knowledge of the effect of different types of institutions over time, A.I.D. should as a first priority concentrate its institutional building efforts on those institutions with a clear multiplier effect, i.e., research and professional agricultural education. The land-grant university is an appropriate (but not the only) model, if suitably adapted to local conditions.

2. Institution building takes time. Creating an agricultural university and bringing it to the point where with indigenous personnel it can undertake advanced agricultural education and research is inevitably a long-term project. A.I.D. needs to develop procedures which will help to assure the continuity of effort essential to the success of such undertakings.

3. A.I.D. should seek to identify more precisely the character and timing of the contribution of different institutions, e.g., extension of precise technical information on the HYV package of practices was essential to rapid diffusion, but the established extension service was only one of several agencies which performed this role. The importance of credit in the HYVP has not been clearly demonstrated. In Pakistan and India the lack of institutional credit appears to have had little significance. In Turkey and the Philippines credit is reported to have been an integral part of the program.

4. Paragraph 3 should be read in the light of the general observation which introduces this section. The HYV campaigns were unique in the agricultural experience of the LDCs, and the extent to which they can be duplicated in other parts of the agricultural sector will probably depend on the availability of additional technological innovations of comparable simplicity and profitability. Even in the HYV campaigns, a more effective extension service and more widely available credit might have accelerated the diffusion process. If the conclusion of many at the conference is correct - that the next step in agricultural development should be crop diversification and an intensified effort to reach the small farmer - extension and credit institutions may well have a significantly greater role to play.

5. Experience with the HYVs demonstrated that co-operative action is readily achieved when the benefits of such action are apparent to the farmers concerned. A.I.D. should take account of this demonstrated fact in planning its programs, and should investigate the potentialities of alternative systems of providing services and of broadening farmer participation in those areas where the HYV's are creating the possibility of institutional evolution and innovation.

6. A.I.D. should endeavor to encourage a greater role for private institutions, particularly those of the LDCs, in performing essential services in the agricultural sector -- wherever it appears that these institutions can lessen the burden on over-taxed governmental institutions, and/or provide the necessary service with greater efficiency.

7. The high-yielding varieties program served to test the availability and responsiveness of the network of national institutions. Their response to the test should be evaluated, and serve as a guide to further programs of institutional improvement. In addition to the emphasis on research and professional agricultural education mentioned in paragraph 1 above, A.I.D. should encourage increased participation of the private sector, for the reason stated in III B 5. Under certain conditions support of other institutions may be desirable:

- a. Extension and credit, to help disadvantaged farmers adopt new technology, and/or to assist in promoting diversification.
- b. Co-operatives, when they have a clearly defined objective and a useful role to play.

V. MAJOR PHYSICAL INPUTS

A. Findings

The so-called high-yielding varieties might be more accurately described as the highly responsive varieties. In response to increased applications of fertilizer, with accompanying protective materials such as insecticides, fungicides, herbicides, and adequate water supplies, they produce yields which greatly exceed those of native varieties.

Overall fertilizer use in the countries covered by this study is expected to grow at the compound annual rate of between 12 and 20 per cent. Increases on acreage planted to high-yielding cereal varieties will be greater.

Fertilizer costs in the LDCs are high -- both for imports and for locally produced materials. Imported materials can be purchased economically in a number of developed countries, but the costs of transport and distribution greatly increases the price. Production from local plants is frequently inefficient.

Possible sources of supply available to the LDCs also include intermediates. Numerous and complex factors enter into the calculation of the most economic means for a particular country. In general the rule of thumb is: imports of finished materials when daily requirements are less than 100 tons of  $P_2O_5$  and 200 tons of N; intermediates where the daily requirement is 100-300 tons of  $P_2O_5$  and 200-400 tons of N; integrated production from raw materials to finished product may be justified where daily requirements exceed these rates.

The HYV wheat varieties require planting at precise depths, and for this purpose mechanical drills are important. A good case can be made for machinery which will speed the harvest and thus facilitate multiple cropping. However, under the conditions of unemployment and underemployment which characterize most developing countries, the utilization of machinery which will displace labor should be discouraged.

The HYV's have been confined predominantly to irrigated areas, plus a relatively small acreage which has an assured supply of rain. This will doubtless continue to be the case, and the spread of existing varieties of wheat and rice will probably be limited to such areas.

The lack of adequate water (and inefficient management of available supplies) is a serious constraint on general agricultural development, and severely limits the spread of the high-yielding cereal varieties. Looking ahead a decade or so, it is likely to be the most serious constraint on agricultural development. The problems are of three sorts--

1. There is grossly inadequate knowledge of the inter-relations of soil, water and plants in most of the LDCs. A substantial volume of additional research is needed, much of it location specific.

2. Additional water which might be supplied is either untapped underground, or wasted as run-off. There are still vast untapped underground resources in the Indo-Gangetic plain, which could be reached by tube wells, thus expanding the area of irrigated land. Much of the rainfall in rain-fed areas (which constitute from 60-80 per cent of the arable land in the LDCs), which could be channeled into catchment areas, is simply wasted.

3. Water which is made available by irrigation works, or by rainfall, is wasted by poor management. In the flat areas of the irrigated plain, water-logging and salinity are constant problems, and they are seldom effectively dealt with. The real potential of irrigation as a means to multiple cropping is largely unrealized. Irrigation systems which flow water over entire plots from the highest to the lowest are wasteful and fail to deliver to each farm the volume of water it requires. Rain-fed areas could be made vastly more productive by small dam construction, improved contouring, water spreading, etc.

B. Implications for A.I.D.

1. The materials developed in the Review are consistent with the A.I.D. fertilizer policy set forth in P.D. 41, which should continue to be applied.

2. A.I.D. should endeavor to discriminate in the types of farm machinery it finances, and concerning which it advises the Government of Host Countries. Certain machinery is essential to proper planting, or to a rapid harvest which facilitates multiple cropping, and the accomplishment of these purposes is clearly desirable. However, machinery which serves merely to supplant hand labor is probably not socially justifiable in most LDCs. Admittedly, in many cases, this principle will not provide adequate program guidance, but one practical conclusion emerges: subsidies or other special inducements for the import or manufacture of machinery likely to supplant significant numbers of laborers is unwarranted.

3. A.I.D. should encourage a substantial increase in research on the inter-relations of soil, water and plants. Much work is needed to make potential water supply available, and to improve the management of available supplies. Programs which support Agricultural Universities and other local research institutions should aim to increase the capacity of these institutions to do research in these areas and to produce graduates skilled in water management -- i. e., control and allocation at the source as well as on-farm use.

4. A.I.D. Missions should encourage host Governments to adopt policies and practices which maximize the utility of available water supplies, to instruct farmers concerning desirable water management practices and to stimulate co-operative village action in applying them.

5. As the use of pesticides becomes more widespread in LDC agriculture -- a development which is now accompanying the diffusion of HYV's -- A.I.D. will need to concern itself with the problems they create.

VI. RESEARCH

A. Findings

Continued growth in agriculture depends on a continuing flow of new technology which can only come from adequate research.

The ability of scientists to manipulate the genetic structure of plants has been applied to problems of food production in the tropics and sub-tropics only in recent years. The success of IRRI in producing IR-8 within a five-year period demonstrates the remarkable breakthroughs which may be accomplished when competent inter-disciplinary teams are mobilized to concentrate on the achievement of specifically defined objectives. Although some progress has been made in widening the knowledge base and increasing the research capacity of the developing countries, the evidence is clear that for the foreseeable future the scientific structure in the LDCs will be inadequate to perform the total task required for sustained agricultural progress. Simultaneous action on two fronts is required:

a. The competence of the LDCs, themselves, to carry on agricultural research must be progressively improved, and the ultimate objective should be to bring each country to the highest level appropriate to its size, resources and agricultural problems.

b. The deficiencies in scientific competence so common throughout the developing world must be compensated for, to the extent possible, by the importation of materials and skills. The mass of the world's scientific skills is now concentrated in the developed countries,

in universities, research stations, foundations, the private sector, and these skills have not as yet been fully mobilized to provide both external assistance and to strengthen indigenous institutions and capabilities. (The provision of scientific skills and improved materials to the LDCs by institutions in the developed countries, incidentally, can serve other than purely altruistic purposes. The research capabilities of these institutions and their teaching competence may both benefit from involvement in the problems of the LDCs.)

Some immediate improvement in many LDCs could be achieved by the more effective use of manpower already trained and available, but ineffectively utilized because of poor organization and being spread too thin through too many institutions. A long-term solution calls for an increase in the total number of scientifically trained personnel.

Among the subjects which merit priority research attention are:

- a. Further adaptation of existing high-yielding rice varieties to specific locations; there is a less acute need for similar work on spring wheats, but back-up strains are needed. Winter wheats and durumms suitable to the high altitude sub-tropics need to be developed.
- b. Improvement of cereals for non-irrigated areas.
- c. Cropping systems for the humid tropics.
- d. Improved knowledge of soil fertility, plant structure, disease and insect control.
- e. Irrigation, drainage, and other problems of water management.
- f. Vegetables and legumes.
- g. Technology of food processing adapted to LDC capability and market potential.

B. Implications for A.I.D.

1. It is clear that there should be a significantly greater investment in research on problems of agricultural development in the LDCs, and on creating additional LDC capability to do research work. This will require a substantial increase in budgetary allocations to agricultural research in many LDCs, and a material strengthening of institutions capable of providing advanced training in the agricultural sciences. It will also require a considerable increase in A.I.D.'s own budget for the support of agricultural research and for assistance to the building of institutional competence in the LDCs.
  
2. Further work is required on wheat and rice for dryland farming, and additional improvements should be sought in corn, sorghum and millets. A concerted effort should be made to develop a profitable technology for the disadvantaged farmers of these areas, comparable to the HYVs developed for areas of assured water supply.
  
3. The question of A.I.D.'s ability to stay for the long pull required for the ultimate achievement of long-term research goals, and to support institutions designed to contribute to these goals, has been raised in connection with the support of agricultural universities in the LDCs and needs to be raised again here. The Agency has supported certain LDC agricultural universities for more than a decade; has engaged some U.S. universities in research over a span of years; and has given letters to both IRRI and CIMMYT stating the intent to contribute to these institutes on a continuing basis. Thus, the Agency is not without

instruments to strengthen its commitment to long-term institutional development, and should make full use of them in the future.

4. Greater stress in A.I.D.-financed projects should be placed on building more research and service capabilities into LDC universities and other institutions:

a. Consideration should be given to the development or arrangements which will permit continued collaboration on research projects between U.S. and LDC institutions after the LDC institution "comes of age" and ceases to require continued support.

b. In strengthening local research competence, A.I.D. should, where conditions are propitious, assist LDCs in reorganizing their research capacity to greater effect. Quality of research is likely to be more important than quantity.

c. To increase the sum-total of LDC capacity, more advanced training of personnel is also required, most notably the agricultural universities (See IV. B.).

5. When A.I.D. considers phasing out the assistance program in a country which is reaching a position where general concessionary assistance is no longer justifiable, special attention should be directed to the stage of research capability achieved, and, where further assistance is required to bring agricultural research institutions to a state of maturity, means should be sought to accomplish this purpose.

6. In seeking to improve the input of skills and materials from the developed world, obviously A.I.D. needs to start from the base which already exists and to go on from there. Steps clearly indicated are the following:

a. Support and strengthen international research centers, particularly in their capacity to assist the LDCs solve production problems and to provide training to nationals of these countries.

b. Continued support for centers of excellence on a long-term basis in the United States--both in the U.S. government institutions and in the Land-Grant universities. (A nucleus of such centers supported by A.I.D. already exists. A.I.D. depends on TVA for its basic work in fertilizers, on the USDA for economic analysis and for certain genetic work. Contracts already exist with a number of Land-Grant universities-- e.g., Purdue in corn and sorghum, Nebraska in wheat, Mississippi in seeds).

c. There are other developed countries and international bodies which have capabilities in this area, and are prepared to contribute. Wherever possible, A.I.D. should encourage such participation, with the object of helping to promote a network of relationships among the various institutions around the world which are involved in related tasks.

7. Properly to encourage and support research will require improved professional competence for A.I.D. This can be done in large measure by use of USDA personnel and consultants, but it is also essential to have some strengthening of A.I.D.'s own in-house capabilities.

8. The Agency needs a clearer overview of the research needs of the developing countries and of the network of institutions which can most effectively meet these needs. The development of a framework for wise decisions concerning the investment of additional research funds is needed. The possibility of performing this task in co-operation with the Foundations and other appropriate organizations - national and

international - should be examined. The objectives of this review would be to determine--

- a. what needs most urgently to be done by external research institutions (i.e., those not part of the LDC system)?
- b. how should these tasks be allocated?
- c. how can results achieved be more effectively tied into programs in the LDCs?

VII-A. EMERGING PROBLEMS: CEREAL SURPLUSES

A. Findings

The HYV program has demonstrated the feasibility of overcoming deficits in cereal production in Asia. Similar evidence applicable to other regions is available. But increases in rice and wheat production do not solve the problem of protein deficiency. In fact, to the extent that the cereals are planted on land formerly used to produce legumes they may even aggravate the problem.

As the HYV program expands, the potential for surplus production emerges, and with it, the need for assessing its effects. Comparative advantage is a better criterion than self-sufficiency, but the latter provides a convenient benchmark.

A few favored LDCs may look forward to a cereal export position. However, the highly competitive nature of the international cereals market and the comparative advantage of some countries, mostly in the developed world, will limit this option for most LDC's. Surpluses created under the stimulus of high price supports or subsidies are unlikely to find outlets in a highly competitive export market. Supply disequilibrium among crops is likely to result from over-stimulation of a few.

With the increased yields afforded by HYVs, a smaller total acreage will be required to meet the country's cereal requirements, even assuming an increase in effective demand for cereals. Given the anticipated limitations on the export market for cereals, it will be necessary to find alternative uses for the acreage thus freed. This development will facilitate desirable diversification to other crops and into poultry and animal production.

B. Implications for A.I.D.

1. Before deciding to support expanded production of a particular food crop in a particular LDC, A.I.D. should consider the following questions:

- a. Is the crop now (or could it become), an important element of the local diet?
- b. Is production already seriously below effective demand, or is it beginning to lag significantly behind the rate of population growth?
- c. How is demand likely to be affected by rising income and population growth? (The effect of high elasticity of demand for food with rising incomes in the LDCs has not always been accurately assessed in the past. A.I.D. needs better data and more accurate analysis in this area, in order to permit effective planning.)
- d. Can production be increased at lower rather than higher costs?

\* 2. As countries move towards self-sufficiency in cereals production, A.I.D. should seek to stimulate progress in the following areas:

- a. Agricultural diversification, to provide a basis for internal consumption patterns and, where comparative advantage can be developed, for export income. There may be possibilities for poultry and animal production in some countries which should not be overlooked.
- b. Development of the market, to expand sales and facilitate diversification. Relief of chronic food deficits will make

it easier for the country to reduce the prices of cereals, to follow an expansionary employment policy through public works which are labor intensive and provide infrastructure for the agricultural sector, or to take other income distribution measures leading to increased food demand.

c. Nutrition education, to play an increasing role in stimulating national demand for higher quality food and the agricultural diversification needed to meet this demand.

d. Development of agri-business, to encourage the processing of cereal preparations and of other products of a diversified agriculture and thereby expand the consumer base, as well as provide increased employment and incomes.

3. Broadened participation by small farmers, both in production campaigns and in general increases in agricultural sector income, should be a continuing preoccupation. Initial response to the HYV is normally among the more alert and advanced farmers. Broad involvement by the less fortunate must be engineered before self-sufficiency is achieved or the resultant market squeeze will probably worsen rural poverty.

VII-B. EMERGING PROBLEMS: SOCIO-POLITICAL EFFECTS

A. Findings

The introduction of HYV in the countries studied has increased wealth, and in most cases probably increased employment. But in some regions it has increased income disparities, within the region, and it has accentuated the disparity between the more productive regions with good soil and adequate water, and those not so well endowed.

These are problems which can now be readily seen; in some cases they were doubtless anticipated. Perhaps policies could have been devised which would have tended to widen the benefits and diminish the disparities which resulted from HYV introduction. Even in retrospect, however, it is not obvious what these policies could have been, given the social, economic and political environment in which the programs had to operate. Certainly a policy of seeking to maintain an equally shared poverty was not a desirable alternative.

The problem of the late adopters in favorable regions and the farmers in dry-land areas - who together make up about 70 per cent of the agricultural population of the LDCs - is serious. Diffusion can and should be widened in favored areas by improved extension, improved credit, and perhaps stronger incentives. But there are obvious limits to such remedial action - those fixed by the boundaries of the favored lands, and those set by the amount of cereal the market can absorb. For the farmers of dry lands, to which irrigation cannot be brought at an economic price, research on dry-land crops ultimately permit their production of a larger share of food grains, as irrigated lands are progressively shifted to higher quality foods. But there is no short-term solution in sight. One of the major

problems is the difficulty of tapping the profits of those who have benefited most from the agricultural innovations. The budgetary resources of most LDCs are severely limited and their problems will grow more acute with the dwindling away of contributions from PL 480. Public necessity as well as simple considerations of equity require that means be found for funneling part of this newly created wealth into the state treasury. A solution of this problem might facilitate progress in leveling disparities and improving the lot of the disadvantaged.

Stresses and strains will continue, and panaceas are unlikely to be revealed by generalized social science research. These socio-political problems tend to be highly location specific, and their solution will depend primarily on the sensitivity of local political leaders. Though A.I.D.-financed research in social science may help these leaders to anticipate problems and to find solutions, it cannot supply sensitivity where none exists.

B. Implications for A.I.D.

1. A.I.D. should encourage LDC policies which --
  - a. Channel part of the profits of farmers most advantaged by introduction of new varieties into productive enterprise and the public treasury.
  - b. Use resources to construct infrastructure which will tend to benefit smaller farmers.
  - c. Provide extension and perhaps credit in a manner to promote diffusion among later adopters.

- d. Provide more jobs in rural areas, e.g., by encouraging labor intensive types of agriculture, food processing and other rural-based labor-intensive industry, and rural public works. (As indicated in VII. B. 2-b, significant additions to the food supply should facilitate the adoption of expansionary employment policies.)
  - e. Do not promote the adoption of labor-saving machinery (for example by making the import or production of such machinery attractive.).
2. Success in persuading host countries to avoid providing special inducements to use labor saving machinery (V.B.2.) and support of an intensified research effort on dry-land crops.(VI.B.2.) would help to diminish socio-political strains.
3. A.I.D. should furnish assistance to those governments which desire to undertake research on the socio-political effects of introducing new agricultural technologies.