AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 78 ARDA

1. SUBJECT CLASSIFICATION
A. PRIMARY: Communications — CA00-0000-G570
B. SECONDARY: General--Asia

2. TITLE AND SUBTITLE
Scientific communication among rice breeders in ten Asian nations

3. AUTHOR(S)
Hargrove, T.R.

4. DOCUMENT DATE: 1978
5. NUMBER OF PAGES: 16p.
6. ARC NUMBER: ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
IRRI

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In IRRI res.paper ser.no.12)

9. ABSTRACT

Data were gathered for a 2-year period on the publication attitudes and records and information-seeking activities of 38 rice breeders at 27 agricultural experiment stations or universities in 10 Asian nations.

When the breeders were asked in which scientific publication they would most like to publish an article on their research, about half indicated journals in the highly developed nations. The breeders had authored or coauthored 183 published papers during the previous 2 years, about 2.4 papers/scientist per year. Fifty-three percent of the articles appeared in national publications; 23% in institutional publications; 18% in journals in highly developed nations; and 6% in international publications.

The distribution of publication productivity was the same as that found among chemists, physicists, and other scientists in the highly developed nations: 50% of the scientific papers published during the 2 years were authored by only six breeders--roughly the square root of the sample of 38 breeders. That suggests that Asian rice breeders have scientific norms similar to those of peer scientists abroad and that breeders' norms do not differ from those of other scientists.

During the 2 years the 38 breeders had prepared or helped prepare 106 papers for presentation to peer scientists at professional conferences; 68% of the papers were presented at national or local meetings; 26% at the International Rice Research Institute (IRRI); and 6% in other Asian nations. The breeders also prepared a total of 344 newspaper or magazine articles, radio broadcasts, extension publications, and teaching materials.

Ninety-two percent of the total scientific literature read by the breeders was in English. The breeders rated the importance and percentage of use of 76 publications and personal information sources. The International Rice Research Institute *Annual Report* received the highest mean rating -- 6.46 on a scale where 7 was the most important -- and the highest rate of use (95%). Rated second most important information source was *local problem-area scientists such as agronomists, entomologists, and pathologists.*

10. CONTROL NUMBER
PN-AAF-274

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Asia
Communication theory
Diffusion
Information
Linkages
Periodicals
Research
Rice
Rice breeders?
Scientists
Technology transfer

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ta-G-1074 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

SCIENTIFIC COMMUNICATION AMONG RICE BREEDERS IN 10 ASIAN NATIONS[1]

ABSTRACT

Data were gathered for a 2-year period on the publication attitudes and records and information-seeking activities of 38 rice breeders at 27 agricultural experiment stations or universities in 10 Asian nations.

When the breeders were asked in which scientific publication they would most like to publish an article on their research, about half indicated journals in the highly developed nations. The breeders had authored or coauthored 183 published papers during the previous 2 years, about 2.4 papers/scientist per year. Fifty-three percent of the articles appeared in national publications; 23% in institutional publications; 18% in journals in highly developed nations; and 6% in international publications.

The distribution of publication productivity was the same as that found among chemists, physicists, and other scientists in the highly developed nations: 50% of the scientific papers published during the 2 years were authored by only six breeders--roughly the square root of the sample of 38 breeders. That suggests that Asian rice breeders have scientific norms similar to those of peer scientists abroad and that breeders' norms do not differ from those of other scientists.

During the 2 years the 38 breeders had prepared or helped prepare 106 papers for presentation to peer scientists at professional conferences; 68% of the papers were presented at national or local meetings; 26% at the International Rice Research Institute (IRRI); and 6% in other Asian nations. The breeders also prepared a total of 344 newspaper or magazine articles, radio broadcasts, extension publications, and teaching materials.

Ninety-two percent of the total scientific literature read by the breeders was in English. The breeders rated the importance and percentage of use of 76 publications and personal information sources. The International Rice Research Institute *Annual Report* received the highest mean rating -- 6.46 on a scale where 7 was the most important -- and the highest rate of use (95%). Rated second most important information source was *local problem-area scientists such as agronomists, entomologists, and pathologists.*

---

[1] by Thomas R. Hargrove, associate editor, International Rice Research Institute, Los Baños, Laguna, Philippines. Submitted to the IRRI Research Paper Series Committee 15 November 1977.

SCIENTIFIC COMMUNICATION AMONG RICE BREEDERS IN 10 ASIAN NATIONS

Scientists have traditionally sought to communicate their research findings through articles in scholarly journals, research reports, and books, and through papers presented to their peers at professional conferences. But scientific information also moves through informal channels. De Solla Price (1963) proposed that modern science moves ahead of traditional channels largely through unofficial institutions that he termed *invisible colleges* -- informal linkages of scientists with similar research interests who share research methodologies and new findings through personal contact, letters, study leaves at other institutions, and preliminary research reports.

Scientific publication and presentation also serve some stronger (although more subtle) purposes -- it establishes the scientist as having first discovered a new piece of knowledge; furthermore, it is a reward mechanism. De Solla Price (1963) wrote that the strong force that called the scientific paper into being and has kept it alive since was the establishment and maintenance of *intellectual property*.

Havelock (1973) wrote that, although scientists have created a system that conveys information fairly well from one scientist to another, that system may not effectively link research and practice or even basic and applied research.

There has been little research on communication among scientists and most of that has been in the highly developed nations -- little is known about the flow of information among scientists in the developing nations, particularly among agricultural scientists.

Some researchers question the relevance of scientific publication in the developing nations, particularly publication in journals in the highly developed nations. They reason that the quality of a paper -- and thus, its likelihood of acceptance for publication -- is often judged by whether it builds upon existing knowledge, i.e., does it extend the *frontiers of knowledge* in that field? Because the frontiers of knowledge to which the developed-nation journals are oriented may be quite different from those in the developing nations, some feel that publication in developed-country journals may misdirect scarce scientific manpower and research funds. For example, to publish in a western journal a scientist may conduct highly theoretical research rather than research that will result in farm technology. Furthermore, because the developing nations do not have strong agribusiness sectors to adapt theoretical research findings to farm technology, such theoretical research may bypass the problems of millions of small-scale farmers (Swanson, 1974).

Jennings et al. (1978) stated that society supports plant breeders for only one purpose: to develop more productive varieties for farm use. They wrote that the only realistic criterion of success for plant breeders in the tropics is the degree to which they increase national rice yields.

As a center for both the use of scientific information and its dissemination to the rice-growing world, IRRI needs information on communication among rice scientists, because they have the ultimate responsibility for developing the improved varieties and farming methods needed to increase food production. Data on information dissemination help IRRI scientists and communications specialists develop more effective means of communication. Questions of interest include: Are rice scientists strongly motivated to publish their research results? If so, where? How much scientific information is available to them? Which sources are of most use in their rice improvement activities?

In 1975 IRRI initiated a research project that included the social aspects of Asian rice improvement programs. A survey was made of 27 agricultural experiment stations and universities in 10 Asian nations. The research centers were of national, regional and state levels and were selected to represent major rice-growing areas. Because a major purpose of the study was to trace the diffusion of genetic materials among local rice breeding programs, the breeders who largely controlled the rice genetic materials were interviewed. Interviews were: Bangladesh, 2 breeders at 1 research center; Korea, 2 breeders at 2 stations; India, 17 breeders at 12 stations; Indonesia, 2 breeders, 1 station; Iran, 2 breeders, 2 stations; Nepal, 1 breeder, 1 station; Pakistan, 4 breeders, 2 stations; Philippines, 1 breeder, 1 station; Sri Lanka, 3 breeders, 3 stations; and Thailand, 4 breeders, 2 stations. Data were gathered on their publication records and information-seeking activities.

The breeders were asked how many scientific papers they had published and in what publications. Other questions measured the extension and teaching materials that the scientists produced. A *Q-sort* test measured the relevance of 76 personal and nonpersonal sources of information used in the breeders' work.

The purpose of the research was to better understand how scientific information moves among Asian rice improvement programs. The author in no way implies that the rice breeders who published the most papers, or even the papers in the most prestigious journals, are necessarily better or worse scientists than the others.

The research project was partially funded by a research grant from The Rockefeller Foundation.

SCIENTIFIC AND EXTENSION PUBLICATIONS

Data were collected on scientists' attitudes toward publication, on the numbers of scientific papers and extension materials that they had prepared and published or presented, and on where they were publishing their research results.

Choice of scientific publication

The rice breeders were asked to name the scientific journal or publication in which they would most like to publish an article about their research results, if they could be assured of publication anywhere in the world. The publications named by 35 breeders -- 3 had no interest in publication -- were classified according to origin as national (intended for scientists within that country and published locally); international (serving the Asian rice-growing region); and from a highly developed nation (U.S., Canada, Europe, Australia, or Japan).

Slightly more than half of the breeders indicated journals in highly developed nations as their first choice for publication (Table 1).

Table 1. Origin of scientific publications named by Asian rice breeders as first choices for publication of articles about their research. Thirty-five rice breeders at 24 agricultural experiment stations and universities in 10 Asian nations, 1975.

Origin of scientific publication	Breeders naming publication as first choice	
	no.	%
Highly developed nations	18	51.4
National	12	34.2
International	5	14.2

The publication most often named was *Crop Science*, a journal sponsored jointly by the Crop Society of America and the American Society of Agronomy It was the first choice of 29% of all breeders interviewed. Of the 18 breeders that preferred to publish in highly developed nations, 10 chose *Crop Science*.

Of the international publications, *SABRAO Newsletter*, published by the Society for Advanced Breeding in Asia and Oceania, was chosen by three respondents. One breeder selected the *International Rice Commission Newsletter*, published by the United Nations Food and Agriculture Organizati (FAO). (One respondent said that he would prefer to publish an article in a journal sponsored by IRRI, even though he realized that no such journal existed.)

Time spent in writing, extension, and teaching

Each breeder was asked to indicate the percentage of his professional time that he spent in different aspects of rice work. The mean percentage was then calculated for each activity.

The breeders spent a mean of 68.4% of their work time in research, but only 4% in writing, 4.7% in extension activities, and 5.7% in teaching and training (Hargrove, 1978).

Numbers and sources of scientific publication

To determine where Asian rice scientists actually publish their research results, each breeder was asked the number of scientific papers or articles authored or coauthored by him and published or accepted for publication during 1974 and 1975. The publications or journals in which those papers were published were later classified as institutional (published by the breeder's own research center), national, international and highly developed nation.

The 38 breeders had published a total of 183 scientific papers during the 2 years, an average of 2.4/scientist per year. Seventy-six percent of those papers were published in institutional or national scientific journals or publications, and about 20% in journals in highly developed nations (Table 2).

Table 2. The scientific articles or papers (written for scientific audiences) that Asian rice breeders had published or had accepted for publication during 1974-75. Data from 38 rice breeders at 27 agricultural experiment stations and universities in 10 Asian nations, 1975.

Origin of scientific publication	Papers published		
	No.	% of total	Av.no./scientist per year
National	97	53	1.3
Institutional	42	23	0.6
Highly developed nations	33	18	0.4
International [a]	11	6	0.1
Total	183	100	2.4

[a] Includes regional publications such as the *International Rice Commission Newsletter* (published by the Food and Agriculture Organization of the United Nations) and *SABRAO Newsletter* (the Society for Breeding in Asia and Oceania).

Presentation of scientific papers

An analysis was made of the scientific papers that rice breeders had authored or coauthored and presented to other scientists at conferences and professional meetings during 1974-75. Thirty-eight scientists had prepared or helped prepare 106 papers -- an average of 1.4 papers/scientist per year. Most of their papers were presented at national or local scientific meetings; about a fourth were presented at IRRI (Table 3).

Table 3. The scientific papers authored or coauthored by Asian rice breeders and presented to other scientists at conferences and professional meetings during 1974-75. Data from 38 rice breeders at 27 agricultural experiment stations and universities in 10 Asian nations, 1975.

Conference or meeting	Papers presented		
	No.	% of total	Av. no./scientist per year
National or local	72	68	0.9
International Rice Research Institute	28	26	0.4
Other Asian nations	6	6	0.1
Highly developed nations	0	0	0
Total	106	100	1.4

Extension and teaching materials

The extent to which the 38 rice breeders were producing information for farmers, extension workers, and students was also surveyed. Each breeder was asked how many extension-type newspaper or magazine articles or radio broadcasts he had prepared, or helped prepare, during 1974-75. Similarly each breeder was asked how many publications for the use of farmers or extension agents he had produced, and how much teaching and training material (for the use of students).

The 38 breeders had prepared or helped prepare a total of 344 articles, broadcasts, extension publications, and teaching materials -- an average of 4.5/scientist per year (Table 4).

Table 4. Extension and teaching activities that Asian rice scientists used to disseminate information to farmers, extension workers, students, and technicians. Data from 38 rice breeders for 1974-75 at 27 agricultural experiment stations and universities in 10 Asian nations, 1975.

Communication channel	Audience	Items prepared by scientists		
		No.	% of total	Av. no./scientist per year
Newspaper or magazine articles, radio broadcasts	Farmers, general public	149	43	2.00
Extension publications	Farmers, extension agents	141	41	1.80
Teaching or training materials	Students, technicians	50	15	0.70
Other	--------	4	1	0.05
Total		344	100	4.55

Distribution of publication productivity: high- and low-publishers

Lotka's law states that half of the publications produced by a population of n scientists are authored by the most productive of about $\sqrt{n}$ of the population.[2/] De Solla Price (1963) wrote: "If one computes the total production of those who write n papers, it emerges that the large number of low producers account for about as much of the total as the small number of large producers." The inverse-square root law has held true from the early journals of the 17th century through the 20th century, and in several scientific disciplines. But most research on the distribution of publication productivity has been conducted in the highly developed nations.

To determine if scientists from Asia differ from their peers in the highly developed nations, and if rice breeders differ from other types of scientists, the number of scientific publications was calculated for each breeder. Fifty percent of the publications were authored by only 6 of the breeders -- roughly the square root of the sample of 38 breeders. And 19 of the breeders (50%) had authored only 11% of the total publications (Fig. 1).

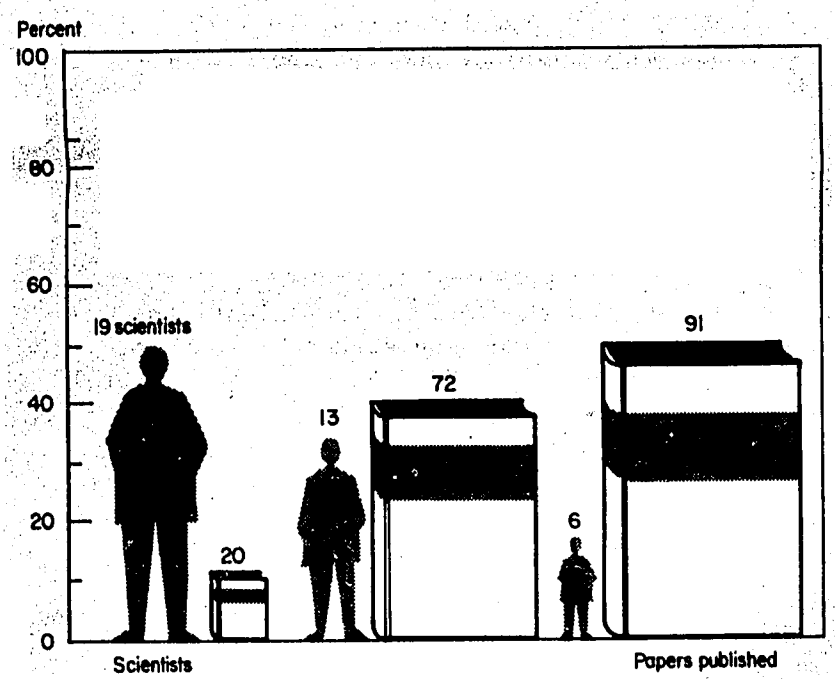

Fig. 1. In a study of Asian rice breeders and the scientific publications that they authored or coauthored over a 2-year period (1974-75), 50% of the scientists had written or helped write 11% of the total scientific articles published by the sample; 16% of the scientists had published 50% of the articles. One hundred and eighty-three scientific articles and contributions to scientific books published by 38 rice breeders at 27 agricultural experiment stations and universities in 10 Asian nations.

2/ The author appreciates de Solla Price's comments (personal communication) which led him to this law.

he 19 *low publishers* -- scientists who each authored three or fewer rticles during the 2 years -- had published a total of 20 articles. ine had produced no publications; four had written one article each; our had written two articles.

'he six *high publishers* had authored or coauthored 91 of the total .83 publications; they averaged 7.6 publications/scientist per year. Wo scientists had published 20 papers each during the 2-year period; ne had published 17; and one, 10.

'he origins of the publications in which the low and high groups had ctually published were analyzed. The six high publishers authored r coauthored 66% of the papers published in the highly developed ations, 55% of the papers in institutional publications, and 44% f those in national publications (Table 5).

Table 5. Origins of scientific publications in which 19 low-publishing and 6 high-publishing rice breeders had published during 1974-75. Thirty-eight rice breeders at 27 agricultural experiment stations and universities in 10 Asian nations, 1975.

Scientists	Scientific publications			
	No.	Av. no./ scientist per year	% of total category[a]	% of scientists' total publications[b]
			Institutional	
19 low publishers	8	0.21	19	40
6 high publishers	23	1.92	55	25
			National	
19 low publishers	5	0.13	5	25
6 high publishers	43	3.58	44	47
			International	
19 low publishers	2	0.05	18	10
6 high publishers	3	0.25	27	3
			Highly developed nations	
19 low publishers	5	0.13	15	25
6 high publishers	22	1.83	66	24

a/ Refers to the percentage of total publications in each category (institutional, national, etc.) that were written by low- and high-publishing scientists.

b/ Refers to the percentage of total publications of the low- and high-publishing scientists that were printed in each category of publication (institutional, national, etc.).

As part of the survey, social characteristics were gathered on the scientists (Hargrove, 1978). When social indicators were compared, it was found that all of the high publishers held Ph.D. degrees, while only 30% of the low publishers held the Ph.D. The high publishers averaged about 3 years older than the low publishers and had about 3 more years of professional experience working with rice (Table 6). They averaged slightly fewer trips abroad.

The high publishers tended to prefer to publish a journal article about their research in journals from the highly developed nations.

Table 6. A comparison of educational and sociological backgrounds of 19 low-publishing and 6 high-publishing rice breeders in Asia. Taken from a sample of 38 rice breeders at 27 agricultural experiment stations and universities in 10 Asian nations, 1975.

Characteristic	Rice breeders	
	Low publishers (19)	High publishers (6)
Highest educational attainment		
B.S. (%)	35	0
M.S. (%)	35	0
Ph.D. (%)	30	100
Source of highest degree		
Local (%)	70	33
Other Asian country (%)	5	17
Highly developed country (%)	25[a]	50
Av. age (yr.)	40.5	43.8
Av. professional experience (yr.)	12.2	15.5
Travel		
Foreign travel (%)	79	83
Trips (av.no./scientist)	2.3	1.5
Preferences for scientific publication		
National (%)	42	17
International (%)	10	0
Highly developed country (%)	32	83
No response (%)	16	0

[a] Of six low-publishing Ph.D.'s, four were educated in highly developed nations. One scientist whose highest educational attainment was an M.S. degree had received the degree in a highly developed nation.

SOURCES OF SCIENTIFIC INFORMATION

Scientific knowledge moves through many channels of communication. Data were collected on the languages in which breeders read scientific literature of rice; on their ratings of the quantity and quality of literature available to them; and on the importance and use of various formal and personal sources of information.

Languages for rice information

Each breeder was asked to indicate the percentage of the total scientific literature of rice that he read in various languages. The mean percentages for each language were then calculated.

Ninety-two percent of the total scientific literature read was in English. Almost 6% was read in national or regional languages. Japanese accounted for 1.5% of the total, and French, Dutch, and German combined accounted for about 1%.

Ninety-seven percent of the scientists indicated that they used English for half or more of their scientific reading. Sixty-two percent read 100% of their rice-related literature in English.

Seventy-one percent of the respondents were from nations that were formerly colonized by English-speaking countries.

Use and ratings of specific information sources

A *Q-sort* methodology was designed and used to measure 37 of the 38 breeders' ratings of the importance and percentage of use of 76 different publications and personal sources of scientific information on rice.

The name of each information source was written on an individual filing card. For each interview, the stack was shuffled and the breeder was instructed to sort the cards into three piles: those that he considered most useful as sources of information; those that he considered least useful; and those sources that he did not use.

After this *rough sort*, seven cards, lettered A through G, were laid out before the scientists. The respondent then distributed the sources that he considered to be *most* important from A to D, according to their usefulness to his program (A was most useful, and D was the middle card).

When the respondent depleted the card supply, he distributed the cards that he felt were *least* important from G (least useful) to D (intermediate).

The cards that the scientist did not use were discarded from the interview.

When this was completed, the position of each source on the distribution was recorded by scoring the positions of the cards on a scale of from 7 (most important) through 1 (least important).

The 37 breeders indicated that they used a total of 885 sources of information, an average of 24 sources/scientist. Twenty-nine of the sources were used by at least one-third of the breeders (Table 7).

The *IRRI Annual Report* received the highest mean rating -- 6.46 on a scale where 7 was most important. Ninety-five percent of the breeders used the *IRRI Annual Report* as a source of scientific information.

Table 7. Percentages of use and mean ratings of importance of various formal and personal sources of scientific information used by at least one-third of a sample of Asian rice scientists. Criterion was usefulness to the scientists in his rice breeding program. From a survey of 77 information sources used by 37 rice breeders at 27 agricultural experiment stations and universities in 10 Asian nations, 1975.

Publication or information source	Scientists who use (%)	Scientists (no.) who rated importance as 1st	2nd	3rd	4th	5th	6th	7th	Mean rating[a]
IRRI Annual Report	95	22	9	2	2	0	0	0	6.46
Problem-area scientists in this country[b]	46	2	6	2	6	0	1	0	5.06
Correspondence and consultation with IRRI outreach scientists[c]	46	2	6	0	5	3	0	0	5.05
Plant Breeding Abstracts (U.K.)	89	7	6	6	7	4	2	1	4.85
IRRI Reporter	97	5	11	5	8	3	3	1	4.83
Indian Journal of Genetics and Plant Breeding	73	2	3	8	12	0	1	2	4.81
Oryza (Italy)	59	1	2	4	12	3	0	1	4.23
Rice Journal (U.S.)	65	1	2	4	12	3	2	0	4.17
Scientific books	81	3	4	6	5	5	5	2	4.01
Rice Pathology Newsletter (IRRI)	70	1	0	7	10	5	3	0	3.96
Japanese Agricultural Research Quarterly (JARQ)	71	2	4	1	9	6	4	1	3.93

Table 7 cont'd...

Indian Journal of Agricultural Science	68	0	3	2	12	4	4	0	3.84
Proceedings of the Crop Society of Japan	38	0	0	2	7	3	1	1	3.57
Current Science (India)	62	1	0	2	10	4	4	2	3.43
Rice Entomology Newsletter (IRRI)	54	0	2	3	6	1	5	3	3.35
Correspondence and consultation with IRRI scientists[d]	86	3	10	6	8	2	2	1	4.81
Crop Science (U.S.)	81	5	5	7	7	4	1	1	4.77
Japanese Journal of Breeding	54	3	5	3	5	2	1	1	4.75
Professional conferences	59	5	3	2	7	1	4	0	4.64
IRRI Research Highlights	84	6	3	6	11	0	3	2	4.58
SABRAO Newsletter	59	1	3	8	4	3	2	0	4.45
Local plant breeders	68	0	5	8	8	1	1	2	4.36
International Rice Commission Newsletter (FAO)	81	0	5	11	7	2	4	1	4.27
Agronomy Journal (U.S.)	78	0	1	2	10	7	9	0	3.28
Canadian Journal of Genetics and Cytology	41	0	1	0	5	6	2	1	3.27
Madras Agricultural Journal (India)	46	0	0	2	7	2	2	4	3.06
Tropical Agriculture (West Indies)	54	0	1	0	7	5	5	2	3.05
Science and Culture	54	0	0	3	6	2	5	4	2.95
Indian Phytopathology	35	0	0	0	5	2	5	1	2.85

[a] Calculated by assigning a weight of 7 to those sources rated most important; 6 to those rated second most important; down to 1 for those rated least important of the sources used. Totals for each category were then divided by the number of breeders that used that source to get mean rating of importance.
[b] Local agronomists, pathologists, entomologists, etc. [c] IRRI scientists who are stationed in the plant breeder's own country. [d] IRRI scientists assigned at Los Baños, Philippines.

The source rated second in importance was *local problem-area scientists in this country* (agronomists, entomologists, pathologists, etc.). Local scientists received a mean rating of 5.06 and were indicated as a source of information by 46% of the breeders. *Correspondence and consultation with IRRI outreach scientists* (stationed in the breeders' own countries rather than at IRRI) was rated third. *Plant Breeding Abstracts*, published in Great Britain, received the fourth highest rating.

CONCLUSIONS AND IMPLICATIONS

Researchers such as Swanson (1974) have suggested that the trend of agricultural scientists in the developing nations to publish articles in prestigious discipline-oriented journals in the highly developed nations may be counterproductive to technology development. This is based on the premise that one of a scientist's main reward mechanisms is professional recognition among his peers, which he attains by publishing in prestigious publications. Because the research published in these journals represents the *frontiers of knowledge* in a specific discipline, the scientist's efforts could be directed toward highly theoretical research rather than toward actually developing needed farm technology.

More than half of the breeders interviewed in this study named journals in the highly developed nations as their first choices for publication of articles about their research; 18% of the total scientific publications authored or coauthored by the same breeders during a 2-year period were published in the highly developed nations.

The distribution of publication productivity of Asian rice breeders was the same as that found among more theoretical scientists (chemists, physicists) in the highly developed nations. That suggests that Asian rice breeders have scientific norms similar to those of peer scientists abroad and that breeders' norms do not differ from those of other scientists.

It cannot be concluded from these data, however, that such norms are actually counterproductive to technology development. A weakness of this study is that it only measures productivity in terms of scientific publication -- not in the development of improved varieties for farmers, which is the primary function of plant breeders. To determine if there is anything more than random interaction between scientific publication record and high technology output, further research is needed to quantitatively measure scientists' development of farm technology and to correlate that measure with publication output.

To further encourage researchers in the developing countries to develop more needed technology for small-scale farmers, the existing reward system should be adjusted. An international journal of agricultural research that emphasizes problem-oriented -- rather than theoretical -- research is suggested as one method to recognize the efforts of those scientists who are working on immediate and pressing farm problems.

Furthermore, additional research should focus on the communication linkages of research scientists to action and extension programs that have the responsibility of taking varieties and usable farm technology to their ultimate users.

LITERATURE CITED

De Solla Price, D. J. 1963. Little science, big science. Columbia University Press, New York. 118 p.

Hargrove T. R. 1978. Rice breeders in Asia: a 10-country survey of their backgrounds, attitudes, and use of genetic materials. IRRI Research Paper Series No. 13. (in press)

Havelock, R. G. 1973. Planning for innovation through the dissemination and utilization of knowledge. Center for Research on Utilization of Scientific Knowledge, Institute for Social Research, University of Michigan, Ann Arbor, Michigan. 460 p.

Jennings, P. R., W. R. Coffman, and H. E. Kauffman. 1978. Rice improvement. International Rice Research Instutute, Los Baños, Philippines. (in press)

Swanson, B. E. 1974. Training agricultural research and extension workers from less developed countries. Ph.D. thesis, University of Wisconsin, Madison, Wisconsin. 406 p. (Unpubl.)