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**GLOBAL REPORT ON THE INTRODUCTION OF SEMI DWARF WHEATS
TO
LESS DEVELOPED COUNTRIES**

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TABLE OF CONTENTS

	Page
I. INTRODUCTION	1
II. WHEAT PRODUCTION	3
III. YIELD COMPARISONS	6
IV. POTENTIAL RESERVES	8
V. AGRONOMIC FACTORS	10
A. Varieties	10
B. Cultural Practices	11
1. Fertilizer	12
2. Irrigation	15
3. Equipment	18
C. Plant Protection	20
IV. ROLE OF THE LOCAL GOVERNMENTS	24
A. Reasons for Developing a New Wheat Program	24
B. Introduction of Semi Dwarf Wheats	26
C. Adaptive Research	31
D. Interrelationships of Institutions	35
E. Promotion of the Program	42
VII. ROLE OF THE FARMER	44
VIII. ROLE OF THE PRIVATE SECTOR	44
IX. ROLE OF USAID	45
X. SUMMARY	50

GLOBAL REPORT ON THE INTRODUCTION OF SEMI DWARF WHEATS
TO
LESS DEVELOPED COUNTRIES

I. INTRODUCTION

1. A great deal of interest and subsequent action has been stimulated by the introduction of new high yielding cereal grains into several food deficient countries. As a direct result of these programs there is now taking place a so called "green revolution." In countries where widespread famines were thought to be only a few years away concerns are now being expressed as to the problems associated with grain surpluses which are anticipated in the near future. It will not be the objective of this paper to make an assessment of the world's food problems but to attempt to identify and evaluate those factors which were responsible in stimulating such a dramatic response in the agriculture sector of some less developed countries.
2. This paper will represent a global report on the development and introduction of semi dwarf wheats into seven countries. Major importance will be placed on the agronomic inputs that were necessary in carrying out the programs. In addition, the role played by the local governments, the private sector, farmers and the United States Agency for International Development will be examined in light of their participation in the wheat programs. Countries where there were large introductions of the new wheat varieties will be emphasized. Factors involving economic policies such as price supports, credit, marketing of wheat, and items such as the purchase of fertilizer and the development of irrigation facilities will be covered by papers directed to these specific phases of the program.
3. The countries reviewed were India, West Pakistan, Turkey, Morocco, Paraguay, Colombia and Mexico. Meaningful comparisons can be made by

contrasting the development of the wheat programs in respective countries. They differ in the length of time the new wheat programs have been in existence, their approach to implementing the programs and the relative success the programs have achieved. In some countries like Mexico, Paraguay and Colombia, active breeding programs have provided a number of high yielding varieties over the years, while in other countries the new wheat programs were launched by massive introductions of varieties developed primarily in Mexico. In some cases a considerable amount of adaptive research was done either as the new varieties were being developed or prior to their introduction, while in one country little or no information was available. In most countries the governments were responsible for initiating the programs while in others progressive farmers played a dominant role. Furthermore, there was a great deal of variation in the technical competency of the various institutions involved and their desire to cooperate with one another. Also, the importance of wheat in relation to other crops differed among the countries. In Turkey, the utilization of wheat for human food is about 420 pounds per person annually, whereas in Colombia and Paraguay it is of minor importance.

4. In evaluating and developing future wheat programs based on the experiences in the countries discussed in this paper, three factors which must be kept in mind are: (1) in those countries where large introductions have been made there has been only six years experience and then only three to four years with a sizeable commercial production; (2) the limited seed supplies of these new wheats were obtained by the most progressive farmers and were grown on the best lands with satisfactory cultural practices. As the seed supplies become more available the total production

should increase, however, a decrease in the average yields per unit area should be expected. Future adaptive research and local varietal development programs could help to offset this decrease. (3) The statistical information are subject to an unknown degree of error and, therefore, should be considered as approximations.

5. In several countries foundations and organizations were involved in addition to AID in developing the wheat programs. No attempt will be made to evaluate the relative contribution of each, but rather to stress how the various agencies complemented each other in their efforts. In countries where the wheat programs have not been so successful there does appear to be a need for greater communication and identification of the respective roles.
6. The resource material for this paper has been developed by the respective USAID missions in the countries discussed and the personal experience of the author with the wheat program in Turkey.

II. WHEAT PRODUCTION

7. The story of wheat production prior to the introduction of the semi dwarf wheats is much the same for the countries reviewed. In most cases there was a slight increase in acreage and production per unit area, however, the total production for any given year was entirely dependent on the climatic conditions which prevailed during the growing season. This resulted in large fluctuations in production from year to year which had a very adverse effect on all segments of agriculture. This condition was further compounded by expanding populations which had forced many countries to become large importers of wheat. Where production was increased in recent years there was evidence of improved cultural practices being used on the local varieties rather than any sizeable increase

in acreage. In India the yield levels per unit area obtained with local varieties has increased substantially from 1958-61 to 1966-67 as the result of improved cultural practices (Table 1). A similar trend was noted for Turkey. In countries such as West Pakistan and Morocco production in terms of yields per acre had remained static.

Table 1 - Yields in lbs. per acre of local varieties of wheat grown in India.

<u>Years</u>	<u>Lbs/Acre</u>	<u>Index 1958-61 = 100</u>
1966-67	2,108	208
1965-66	1,838	190
1964-65	1,978	195
1961-64 (4 yr. average)	1,715	169
1958-61 (3 yr. average)	1,015	100

In Table 2 a three year summary is presented showing the number of acres and total production of local and semi dwarf wheats. With the exception of Mexico, where approximately 90 percent of the total wheat acreage is devoted to the new varieties, countries such as India and West Pakistan are just beginning to have sufficient seed stocks available for a significant commercial production. In these two countries the new varieties account for about 15 to 20 percent of the total acreage in 1967-68. In Turkey, the first large increase was in 1967-68 and amounted to about two percent of the total acreage, however, it is interesting that this limited acreage accounted for about four percent of the total production. In Colombia a drop in total production can be observed between 1965-66 and 1966-67, however, by 1967-68, due to additional acreage, the production increased.

8. The question as to whether the new varieties are increasing the total acreage devoted to wheat by replacing other crops or substituting for

Table 2 - The number of acres and total production of local and semi dwarf wheats for the countries reviewed.

Country		1965-66		1966-67		1967-68	
		No. Acres (000)	Production (000 MT)	No. Acres (000)	Production (000 MT)	No. Acres (000)	Production (000 MT)
Morocco	LV	4,041	812	4,387	1,090	4,883	2,411
	SDV	--	--	--	--	.5	NA
Turkey	LV	19,644	8,200	20,015	9,000	19,966	7,805
	SDV	--	--	--	--	420	595
West Pakistan	LV	12,600	3,786 (LT)	12,900	3,980 (LT)	12,300	4,200 (LT)
	SDV	12	14	255	220	2,500	2,100
India	LV	31,260	10,424 (T)	31,710	11,393 (T)	36,845	16,568 (T)
	SDV	7.4	NA	1,278	1,278	7,269	7,843
Mexico ¹	LV	--	--	--	--	--	--
	SDV	1,423	1,612	1,882	2,058	1,792	1,894
Columbia ²	LV	272	125	168	80	230	125
	SDV	--	--	--	--	--	--

¹Improved wheat varieties represent over 90 per cent of the acreage.

²Improved varieties developed by local country.

existing wheat acreage can also be noted. In India there does appear to be a sizeable increase in wheat acreage between 1966-67 and 1967-68 which could in part be explained by a shift to new varieties in the irrigated areas. In Turkey, where new land has been taken for wheat production, it has been at the expense of needed pasture lands. However, this increase has been offset by the return of a significant amount of old wheat land to pasture as a result of deterioration due to erosion. Comments made by the respective missions would support the conclusion that there has not been a significant amount of land brought into wheat production at the expense of other crops. The one exception would be in Colombia where, with renewed interest in wheat production, the increased acreage has been at the expense of barley and to a lesser extent potatoes, soybeans, pastures and sorghum.

9. In Mexico where the semi dwarf wheats have been in production a number of years the wheat acreage nearly doubled from 1949 (535,000 hectares) to 1957 (958,000 hectares). However, since 1957 the acreage has decreased slightly with the increased production being the result of improved varieties with high yields per unit area being obtained.

III. YIELD COMPARISONS

10. When comparing the increased yield per unit area of the semi dwarf varieties with the local varieties it must be remembered that the new varieties have been grown on the best land and for the most part under better cultural practices. Also there is very little data available where valued comparisons can be made. In India, where both the local and semi dwarf varieties were grown on the same farm, the yields in pounds per acre were 1,395 and 2,471 respectively. The total average yield for new wheats for the 1967-68 crop year in India was 2,365 pounds per acre

with the range being from less than 2,000 lbs. per acre to more than 6,600 lbs. per acre. In West Pakistan the yield of the new varieties has been approximately 1,600 lbs. per acre, while the local varieties also grown under irrigation have yielded approximately 900 lbs. per acre. The yields obtained in Turkey with the new varieties during the 1967-68 crop year were 3,124 lbs. per acre with the local varieties yielding just over 1,000 lbs. per acre. These figures include both irrigated and non-irrigated wheat grown along the coastal areas. The yield per unit area in Mexico has continued to increase. Prior to the release of semi dwarf wheats in 1949 the average yields were 1,200 lbs. per acre whereas in 1968 the average yield was approximately 2,100 lbs. per acre. One interesting observation which can be made is that even though the new varieties are irrigated with higher levels of fertilizer being used, the average yield levels are still quite low. The fact that yield levels over 6,000 lbs. per acre have been obtained would suggest that there is a real need for adaptive type research and the dissemination of the proper information. That there are some unanswered questions regarding cultural practices was shown by some work conducted in India (Table 3). In studying various fertility levels, seeding dates and number of irrigational applications, little or no relationships were found between these factors and yield. In fact, where the most fertilizer was applied the yields were the lowest. This latter point may well stress the need for an expansion and use of soil testing laboratories so that some guidance can be obtained in making recommendations. A similar response has been noted in studies where weeds were a problem, particularly under high fertility.

Table 3 - Factors associated with yield variations with semi dwarf wheats grown in India.

Cases	Average Yield (lbs/ac)	Plant Food: lbs/acre			Aver. No. Irr.	Aver. Seeding Date	Aver. Harv. Date	% Reporting Some Damage
		<u>N</u>	<u>P₂O₅</u>	<u>Total</u>				
6	5,390	89.6	24.7	114.3	8.3	Nov. 12	Apr. 25	83%
6	4,470	80.3	19.2	99.5	6.5	Nov. 17	Apr. 28	0
6	4,210	87.0	28.5	115.5	7.3	Nov. 10	Apr. 20	50
6	3,870	65.9	15.9	81.8	8.3	Nov. 10	Apr. 24	33
6	3,080	99.4	28.2	127.6	8.1	Nov. 7	Apr. 24	33

IV. POTENTIAL RESERVES

11. Some indication as to when the countries reviewed might reach self-sufficiency can be gained from the experience in Mexico. In Table 4 wheat production in terms of average yields, area planted, total production and percentage of new wheats grown is presented. Mexico was self-sufficient by 1958, only ten years after the first new varieties were released, and by 1962 wheat was being exported. Realizing there are many other factors which are different in other countries, nevertheless, most estimates indicate that there will be a smaller time lag between the introduction of the new wheats and when self-sufficiency is realized. India is expecting to be self-sufficient by 1974. Plans for handling surpluses within the next two years are being made in West Pakistan. While in Turkey surpluses are expected at the end of this year, which is only two years after the first major introduction of the new wheats. If Morocco continues to develop its new wheat program TVA estimates indicate the country should be nearly self-sufficient by 1974; however, with predicted population growth and limited land resources increasing deficits will be realized.

12. In Paraguay and Colombia wheat is a minor crop and farmers do not consider it as an indispensable food item since many substitutes are available at the farm level. Therefore, the question of surpluses should not be considered in the same light as with the other countries.
13. In Mexico some idea as to what may happen after self-sufficiency is reached and a need for keeping the supply in line with demand can be noted. The role of the government was to reduce support prices in the more productive areas and at the same time encourage the growing of other crops such as sorghum and safflower by increasing their support price. The reduction in wheat acreage is attributed in part to the increase in sorghum production, however, this is not fully documented.
14. It should be pointed out, however, that the substitution of various crops for wheat could be quite effective, since in many countries wheat is grown under irrigation which expands the potential number of crops which could be grown. Row crops such as vegetables and perhaps some specialty crops might well provide the most economic return in the future. This will be particularly true when more information is gained on how to increase wheat yield on the dryland areas. In the case of Turkey four fifths of the potential wheat growing land is on the Anatolian Plateau. If through proper moisture conservation practices, and improved varieties, yields can be increased it is this land which does not have the flexibility of cropping practices which should produce the wheat. Areas where the new wheats are currently being introduced should then shift into other crops.

Table 4 - Estimated yields per hectare, area planted, total production and proportion of the total area devoted to semi dwarf wheats in Mexico.

	Yield Tons per Hectare	Hectares (000)	Production Metric Tons (000)	Proportion of Area Percent
1950	.91	68	587	11.8
1955	1.10	577	850	77.0
1960	1.42	808	1,190	97.7
1962	1.95	747	1,455	96.2
1965	2.35	807	1,609	89.1
1968	2.64	789	1,894	90.0

V. AGRONOMIC FACTORS

A. Varieties

15. The agronomic input which has received the greatest attention has been the development of the new semi dwarf wheat varieties. The first semi dwarf wheats had the Norin 10 germ plasms which enabled the plant breeders to not only shorten the straw but develop varieties with stiff enough straw to withstand high levels of nitrogen without lodging. However, these varieties offer a great deal more than just short stiff straw in that they reflect a philosophy of plant breeding. Dr. O. A. Vogel and Dr. N. E. Borlaug, who have lead the way in developing semi dwarf wheats, both utilize the concept of stressing the germ plasm in developing new varieties. As a result, the new semi dwarf varieties are extremely wide in their range of adaptation. By adding the photoperiod insensitive factor into these wheats Dr. Borlaug has extended this adaptation. The new wheat varieties also possess many other superior agronomic traits.

One of the most important being the earlier maturity of the new wheats. For example, in the non-irrigated areas of Turkey soil moisture becomes limited in the spring, however, the new wheat matures prior to this stress. Also in situations that are found in India the new wheats tend to mature before various diseases become important. In terms of cropping practices the new early maturing varieties are well suited to double cropping with such things as corn, potatoes, sorghum and rice. However, cotton apparently does not do well following wheat during a single season. It is this concept of developing wheat varieties which have a genetic potential for wide adaptation which has made the successful introductions of these varieties into many different environments possible. Also, as a result of this wide adaptation a reduction in the year to year variation in production could be avoided, a problem which has plagued these countries for years.

B. Cultural Practices

16. A very important point which must be kept in mind is that if wheat yields are to be increased it must be the result of a package of practices. The semi dwarf varieties had been tested in many countries for a number of years without their yield potential being determined. This was due to the fact that the same cultural practices used for the local varieties were employed. In addition to other limitations this often meant little or no nitrogen fertilizer being used which resulted in the semi dwarf wheats doing no better than the local varieties. Therefore, the importance of the package concept that the right set of cultural practices must be employed is just as important as the new seed. In the countries reviewed this was one of the most difficult tasks in trying to convince farmers that they had to change their farming practices. Many times the practices suggested

would be completely opposite from their historical way of farming - such as the use of nitrogen. The farmers knew from previous experience that if they put nitrogen fertilizer on wheat it would lodge. It was also difficult for the farmers to realize that the seeding rates could be materially reduced because of the tillering capacity of the new wheats. However, the various mission reports always made the point that once a farmer was convinced that the new practices would be beneficial they would at least in part be accepted.

17. As a result of the clear-cut need for changing the existing cultural practices, new policies had to be developed to meet the resulting demand for fertilizer, irrigation, machinery, pesticides, etc. Therefore, the impact that the new varieties had on other segments of agriculture and even non-agricultural related areas was as great or greater than the new varieties were to the farmers.
18. The areas which received the greatest attention were: (1) availability of fertilizer, (2) irrigation facilities, and (3) suitable machinery.

1. Fertilizers

19. Data regarding the input of fertilizer in Mexico is difficult to obtain. However, the best estimates would suggest that 60 percent of the irrigated land was fertilized with approximately 68 percent of the total quantity of nitrogen, phosphate and potassium being used on this land. Since most of the new wheat varieties are grown on irrigated land it would appear that fertilizer has played a major role in increasing wheat yields.
20. In India data is also lacking, however, the mission report noted that fertilizer is only used on irrigated or rain-assured acreage which amounts to about one half of the total wheat acreage. The recommended rates for local varieties are from 15/15/0 to 45/22/25 lbs. per acre, while 80/60/40

to 100/60/40 lbs. per acre suggested for the semi dwarf wheats. In the following Table are the estimated amounts of fertilizer used on the semi dwarf wheat during the past three years in India.

Table 5 - Estimated amounts of fertilizer used on semi dwarf wheats.

	<u>N</u>	(1,000 Tons) <u>P₂O₅</u>	<u>K₂O</u>
1966-67	30	15	9
1967-68	165	82	50
1968-69	247	124	71

The large increase since 1966-67 can be attributed to: (1) the increase in acreage of semi dwarf wheats, (2) increase in amounts of irrigated land, and (3) more favorable rainfalls during 1967-68 and 1968-69.

21. The government's Planning Commission Survey of 1967-68 found that 74 percent of the farmers sampled used nitrogen at about 33.5 lbs. per acre, 50 percent used P₂O₅ with averages of 42 lbs. per acre, while very few of the farmers used Potash. Fertilizer applications to local varieties were much less even with irrigation.
22. With the introduction of the new wheats and the large increase in irrigated lands the use of fertilizer in West Pakistan has played a key role to increased wheat production. Since the distribution of fertilizer in the public sector was inefficient the government changed its policy on fertilizer distribution in 1967. Private enterprise was then given the major responsibility for distribution, sales and promotion of fertilizer. It has been estimated that in 1965-66, 33,000 metric tons of nutrients were used on wheat, while in 1967-68 a total of 95,000 metric tons was applied. There is no data available regarding the rates applied by the farmers but it is thought to be similar to the figures presented for India.

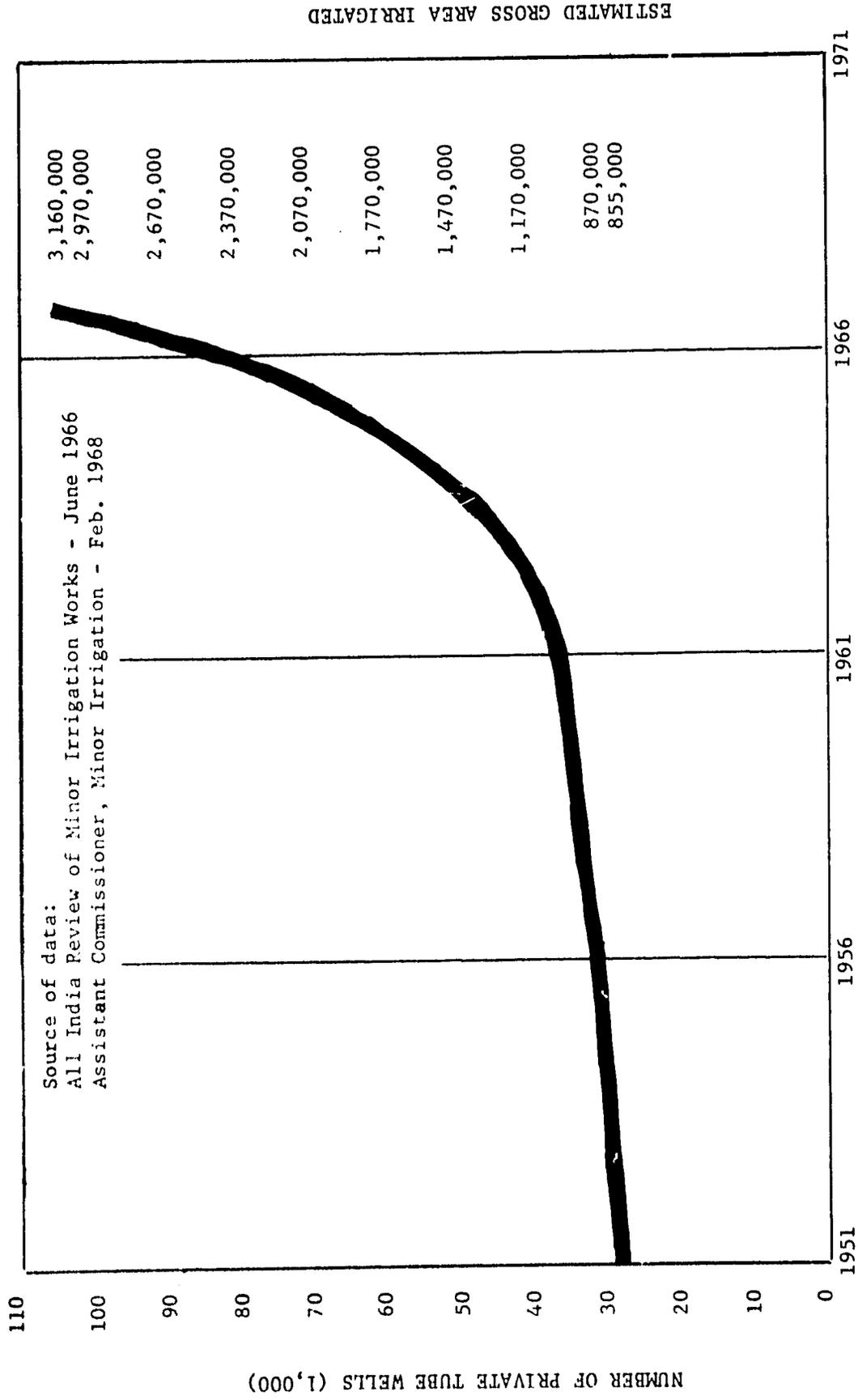
23. The importance of fertilizer to increasing yields of the new wheats is now well understood by the progressive farmers and government officials in Turkey. According to the State Planning Organization, fertilizer applied to wheat was estimated at nearly 90,000 nutrient tons in 1967 with a projected use of 365,000 tons by 1972. The immediate demands will have to be obtained largely by imports (78 percent of the total consumed in 1968) until domestic production facilities come into operation. Indications are that the use of fertilizer in 1968-69 will be less than anticipated due to a shortage of supply and with more farmers now in the program who are not convinced or informed of the necessity of applying the correct amount of fertilizer. Recommended fertilizer rates for the new wheat varieties are 36 lbs. per acre of nitrogen and 72 lbs. per acre P_2O_5 as super phosphate (16 to 18 percent) with an additional 72 lbs. per acre of N in the spring.
24. In Colombia the total amount of fertilizer used has increased about two fold since 1960, however, the amount applied to wheat has decreased. Estimates indicate that 90 percent of the wheat planted was fertilized in 1963, while in 1966 only 62 percent of the wheat acreage received fertilizer which in part contributed to the decline in production during this period. Increases in yields per area through 1968 are thought to be largely the result of improved varieties.
25. In summary, it would appear that the necessary input of fertilizer and particularly nitrogen as a factor in producing more wheat has been well accepted by all the countries reviewed. In some cases rather drastic changes in policy were necessary; however, the local governments were willing to make the necessary adjustments. The fact that there is an indication where some of the farmers are not using the recommended amounts

is not surprising when it is recognized that little or no fertilizer was used on wheat prior to the introduction of the semi dwarf wheats other than limited amounts of P_2O_5 . This factor merely points out the need for additional education and research. In Colombia the relative economic position of wheat in relation to other crops no doubt contributed to the reduction in the amount of fertilizer used rather than any misunderstanding of the role of fertilizer on increasing yields.

2. Irrigation

26. The increase in irrigated land is very closely related to the introduction of semi dwarf wheats. As pointed out in the report from Mexico, the life blood of the improved varieties is provided by water.
27. In Mexico essentially all the wheat is provided regular irrigation since nearly 95 percent of the grain is raised in various irrigation districts. In terms of area the districts account for over 80 percent of the wheat land. The expansion of irrigated land has been the result of an intensive program by the Mexican government. It has been estimated that investments for irrigation have been over 90 percent of all direct public investments in agriculture.
28. Data is somewhat limited as to the impact the new wheats have had on increasing the amount of irrigated land in India. However, it is recognized that if full benefits are to be obtained from the new wheats they must have water. In 1954-55, 12 million acres was irrigated for wheat and in 1965-66 this acreage was increased to 13 million. All the new varieties are currently being grown under irrigation. Much of the irrigated land comes from government controlled canal sources, however, there has been a phenomenal growth recently of private tubewells (Figure 1). These tubewells

Figure 1 - GROWTH OF PRIVATE TUBEWELLS



ESTIMATED GROSS AREA IRRIGATED

have the advantage of assuring year around water which is under the direct management of the farmers.

29. In West Pakistan the new varieties have been grown entirely on the irrigated land. Since the first semi dwarf varieties were introduced in 1965 there has been an increase of 1.3 million acres of irrigated wheat. This increase was made possible by the increased availability of water brought about by the rapid introduction of tubewells, both private and public. The number of private tubewells has increased from 35,000 to 60,000 during the period from 1965-1968. It is interesting to note that, as a result of the increased yields of the new wheats, tubewells are now economically feasible and a high percentage are financed by private money. No estimates are available as to the total possible number of tubewells nor was there any mention of a significant lowering of water table due to the increased number of wells.
30. The government of Turkey has devoted a great deal of effort in developing irrigational facilities by building large dams and main canals. A major problem has been in trying to insure an efficient and timely "on farm" water use. Unlike the other countries reviewed only a very small percentage of the new wheats have been grown under irrigation, however, the amount of rainfall and its winter pattern have resulted in high yields in the Mediterranean and Aegean regions. Some of the new wheats are being grown from spring planting on the Anatolian Plateau under irrigation.
31. Usually in Morocco the rainy season coincides with the growing season and irrigation is only used to save the wheat crop during dry years. Also other crops such as citrus, other tree fruits, cotton, vegetables and grapes bring a higher economic return so they receive the irrigation

rather than wheat. Preliminary data on the new wheat varieties has indicated that it is possible to produce as much as 7,560 lbs. per acre which may change the irrigation practices in favor of more irrigated wheat. Wheat production is largely at the higher elevations in Colombia where rainfall is adequate and well distributed. As a result little or no wheat is grown under irrigation in Colombia. Similar conditions are reported in Paraguay.

32. It would appear that the new wheats have greatly stimulated development of irrigational facilities in several countries. In many respects this has been even greater than the increased fertilizer production in countries such as West Pakistan. The total number of acres which can be put under irrigation is not known. Also such factors as the level of the water table where tubewells are involved and the economic position of growing wheat in relation to other crops will determine the amount of wheat that will be irrigated. To date the amount of irrigated land available has not been a limiting factor in the introduction of new wheats.

3. Equipment

33. In many of the countries reviewed the need for suitable equipment was the major limiting input. The one exception being Mexico where it is estimated that 79 percent of the irrigated land is fully or partially mechanized. When the total cropland is considered the comparable figure is about 29 percent.
34. There is a critical need for suitable equipment in India. This is particularly true for drills and threshers. Since the new wheats require a more exacting planting depth if good stands are to be obtained, grain drills are more desirable than broadcasting seed. In addition, the higher yields are causing a very real problem since most of the wheat

is still harvested by hand. There is also some indication that as much as 15 to 30 percent loss in production is due to a lack of land leveling. This latter factor would also be important in developing suitable lands for irrigation.

35. The new wheat program in West Pakistan has been carried out without any additional inputs of equipment. This has resulted in an additional requirement for labor which is not always available during the critical periods and serious losses in production have occurred. This factor, plus the increased cost of labor, has made the use of combines and threshers economically feasible. Due to the increased demand for equipment the government has sanctioned a 1.5 million dollars of foreign exchange for the importation of combines with additional funds being requested by the GOP for this purpose. The IDA has loaned the government 42 million dollars for farm machinery, much of which will find its way to the wheat program.
36. Trends toward rechanization have increased sharply in Turkey in recent years, however, the use of animal draft power and the number of animals kept for draft have not changed materially. Limitations have been noted in the use of tractors due to a lack of experience in upkeep and a shortage of foreign exchange for parts. It has been estimated that the requirements for machinery will be doubled by 1972. Two factors are responsible for this increased demand. The first is the impact of the semi dwarf wheat varieties along the coastal areas. The second factor will involve the need for special types of equipment for the summer fallowing programs on the Anatolian Plateau. There has been an increased interest on the part of small equipment manufacturers in the private sector which are expanding their production to meet the anticipated

demand. This is regarded as a very important factor in terms of Turkey's overall future development.

37. As Morocco moves into the production of the new wheat varieties, 80 percent of the farming is by traditional methods which includes using animal traction and wooden plows. In the modern sector the farms are usually completely equipped with modern tractors, plows, discs, drills and combines. The Ministry of Agriculture currently has a limited supply of tractors for commercial hire and there are plans to increase this number before 1972. Funds will also be made available to encourage private purchases of tractors.
38. Of the major inputs discussed it would appear that the availability of equipment has been the greatest limiting factor to date. This could be one of the major reasons why the average yields for the semi dwarf wheats are still quite low. This limitation appears to be recognized by the local governments and programs are being initiated to solve the problem. It would appear that this is one major area where the private manufacturing sector could make a very real contribution. The equipment needed involves all phases of farming and in addition to the most obvious such as tractors, drills and combines, consideration should be given to implements necessary for developing good seed beds. Also if the private sector should become involved the idea of promoting sales and servicing equipment which has been sold should be developed.

C. Plant Protection

39. In the countries involved in this review agricultural chemicals have been used largely on industrial crops such as cotton, fruits, olives, grapes, etc. with little or no use being noted on cereals. The only

chemical regularly used on wheat is 2,4D for weed control and some insecticides for insect and rodent control in stored grain.

40. An average figure taken from several sources indicates about 10-12 million acres of wheat were treated last year in India which included both seed treatment and insect and rat control measures. It is estimated that 18 million acres will be treated in 1968-69 (Table 6).

Table 6 - Estimated use of pesticides on wheat since 1963-64 in India.
(figures in million acres)

<u>Year</u>	<u>Total Cropped Area</u>	<u>Seed Treatment</u>	<u>Rat Control</u>	<u>Insect Treatment</u>
1963-64	33.34	2.0	0.8	1.2
1964-65	33.25	2.3	0.9	1.4
1965-66	31.27	2.6	1.0	1.6
1966-67	31.71	3.9	1.6	2.3
1967-68	36.85	5.8	2.3	3.5
1968-69 (Target)		9.0	3.6	5.4

41. Diseases attacking wheat are not only numerous in the countries reviewed but can severely reduce yields in specific areas during a given year. Furthermore, with the introduction of new cultural practices and varieties which tiller profusely the micro-climate within a wheat field is conducive to disease problems, particularly under irrigation. All three major rusts, including Puccinia graminis tritici (black or stem rust), Puccinia recondita (brown or leaf rust) and Puccinia striiformis (yellow or stripe rust) and no doubt different races or biotype of these exist in all or part of the wheat growing regions considered. Other diseases noted are Alternaria triticina (leaf blight), Helminthosporium species of leaf blight, Ustilago

tritici, (loose smut), Tillertia caries and T. foetida (common bunt), Septoria tritici (septoria leaf blotch), Erysiphe graminis tritici (mildew), and some indications that the root rot complexes are present. The latter disease could become a serious problem where wheat is grown under irrigation, particularly when wheat follows wheat in a rotation. By far the best control is resistant varieties.

42. Some concern has been expressed regarding the introduction of large quantities of varieties which were developed from similar germ plasm. The point being that, should a new physiological race of one of the rusts develop, there could be a serious reduction in production. This potential problem is lessened in part by the breeding procedure used in developing the new varieties since extensive trials and evaluations were made regarding their reaction to various pathogen. However, it is very important as plant breeders in the local countries develop their own improved varieties that they do introduce diverse germ plasm in an effort to obtain additional sources of resistance.
43. Little or no damage has been reported by insects in the fields of wheat, however, there have been local outbreaks of leaf feeding caterpillars, grasshoppers, spider mites, shoot fly and aphids species. Due to the increased production and the lack of satisfactory storage facilities, losses have been reported due to insects and rodents contaminating the stored grain. Some of the more important stored grain insect pests which were reported include the grain weevil, grain moth, grain borer, Kopra beetle and flour beetle. In several countries programs are underway to design storage bins for the small farmer which prevents deterioration and insect infestation of grain for a year or more.

44. As a result of improved cultural practices, growing conditions will also be more favorable for pests which compete with the wheat plant for nutrients and moisture. It is well recognized that in areas where semi dwarf wheat varieties have been grown for a period of time that these wheats cannot compete nearly as well with weeds as standard height varieties. Furthermore, when moisture and fertilizers are applied weed species also respond not only in greater growth but with a greater diversity of the species. In Europe and North America, the use of improved fertility and other production practices have been associated with grass weeds, such as Bromus tectorum, Avena fatua, Alopecurus myosuroides, Lolium multiflorum, Agropyron repens and Agrostis sp. becoming serious problems. This has been heightened by the resistance of these grasses to the 2,4-D type herbicides normally used in wheat for broadleaf weed control.

45. Work in India reported by the Indian Agricultural Research Institute, New Delhi, summarized losses measured in nine detailed experiments from various locations. These showed weed losses in wheat ranging from 6.3 percent to 34.8 percent. The average of all nine experiments was 18 percent. Reports from Uruguay have indicated yield losses up to 50 percent have resulted from the lack of weed control. Similar findings in Chile were observed in controlling wild oats Avena fatua. The use of selective herbicides increased wheat yields by 34 percent.¹

46. Since pesticides must be considered as an essential part of the package of cultural practices it can be expected that their use will expand not only in quantity but in the number of chemicals used.

¹/ International Plant Protection Center, Oregon State University
Corvallis, Oregon.

VI. ROLE OF THE LOCAL GOVERNMENTS

A. Reasons For Developing a New Wheat Program

47. There are many factors which can be cited that contributed to the decision of the local governments to embark on a wheat improvement program. Some of the factors are quite obvious while others are more subtle and not as clear. Certainly the technological breakthrough resulting in the development of semi dwarf wheats which were widely adapted to many environments must be considered as one of the more important factors. This, plus the fact that these new varieties received such widespread publicity in the popular news media, made many less developed countries look at Mexico as a country which changed from an importing to an exporting position in just a few years. This came at a time when the United States "so called surpluses" were being exhausted and there was some talk of changing the PL 480 program. Furthermore, the U.S. government had announced that aid receiving countries must pursue "self-help" measures in agriculture.
48. In the local countries several years of drought had reduced wheat production and governments had to make heavier commitments of foreign exchange in order to be assured of sufficient imports. This was coupled with the fact that local wheat prices were very high. Also, even though many government officials were skeptical of the prospects of new varieties they did unofficially support the testing of those varieties which were introduced by the Rockefeller and Ford Foundations, FAO and USAID into the various countries. The fact that these varieties were so well adapted to the growing conditions of the local countries and did not develop any significant insect or disease problems pointed to the soundness of introducing large quantities of these new varieties. It should

also be pointed out that assistance was provided from several sources including the agencies previously mentioned in being sure that these new varieties were tested and evaluated under suitable cultural practices so that their yield potential could be demonstrated.

49. There were other internal problems such as increasing populations of the countries and the desire of the progressive farmer to change and try to better himself. In the case of Turkey, a group of private farmers collectively financed the first large increase of seed and even though the new variety was subject to varying cultural practices the farmers were able to demonstrate the superiority of the new wheat over the local varieties. There were also, no doubt, internal and external political motivations involved as well.
50. Once the decision had been made by the governments, strong groups within the governments and, in some cases, strong individual government officials took it upon themselves to make the programs go. West Pakistan had the strong personal participation and support of the president which was passed on to other officials who in turn focused the attention of the farmers to the fact that changes were needed. The president's insistence on flour prices and funds for an effective price support program along with the importation of large quantities of seed and adequate fertilizer stocks contributed to the atmosphere for success.
51. In Turkey the Minister of Agriculture played a very dominant role in giving the wheat program top priority. His influence was not only felt within his own ministry, but influenced related agencies such as the Agricultural Bank and the Ministry of Finance. When the program was attacked the Minister responded immediately, personally and effectively with full publicity.

52. These are only two examples of the type of commitment the wheat programs had from the government officials. Similar individuals could no doubt be singled out either collectively or alone who played similar roles in the other countries. The important consideration is, however, that in identifying those factors which contributed most to the success of the wheat program, the fact that the governments were ready to change was the most important. The governments were ready to commit resources from not only the agricultural segment but related sectors as well. Sufficient pressure was brought to bear so that agencies within the government and within agriculture worked together, which in many cases was for the first time. Also if longstanding policies or prior procedures were not effective in getting the job done they were changed. Changes in policy varied from modifications in terms of support prices and ease of obtaining credit to a complete reorganization of various institutions within the government. These also included a greater involvement of the private sector in such activities as seed multiplication, fertilizer distribution, developing of irrigational facilities and manufacturing equipment. One of the more lasting benefits of the new wheat programs will be the impact it has had in pointing out the need for change and perhaps an even more significant factor is that the governments did make some of the necessary adjustments. In considering the massive programs that were undertaken during such a short period of time, the role of the local governments cannot be overestimated.

B. Introduction of Semi Dwarf Wheats

53. In describing the impact of the new varieties, it is necessary to consider the status of the wheat program prior to their introduction. The story of the Rockefeller Foundation involvement in Mexico is well

known and described by Stakman et al.¹ In 1962 a study was undertaken in India to determine those factors which were limiting yields and causing the great variation in production from year to year. The observations noted in India were very similar to the conditions existing in the other countries reviewed. The factors included: (1) the local varieties of wheat had been developed over a period of years in such a manner that the potentially high yields were not possible even under good growing conditions; (2) the varieties were, for the most part, tall and would lodge readily, particularly under late irrigations and even under low nitrogen levels; (3) due to the late maturity the plants experience both atmospheric and soil drought during the critical grain filling period. Also late rains and hail storms occurring during this stage of growth also induced lodging; (4) many of the local varieties were susceptible to the major rusts diseases and to loose smut. In fact where farmers had tried to irrigate and use more fertilizer the diseases became more severe. In addition to the limited yield potential of the local varieties the types of cultural practices such as preparing an adequate seed bed did much to limit total production.

54. As a result of the study it became apparent to the Indian government that radical changes were needed. These changes were initiated in 1963-64 when Dr. N. E. Borlaug visited India to evaluate the wheat growing potential and, as a result, introduced several varieties and selections of the new semi dwarf wheats for testing. From the results of these trials and additional tests conducted in 1964-65 where additional information on the

¹ Campaigns Against Hunger. Stakman, E.C.; Bradfield, R. and P.C. Mangelsdorf.

pathological, physiological, agronomic and quality evaluations were obtained, 250 tons of two varieties, Sonora 64 and Lerma Rojo were imported from Mexico. The seed was distributed to the State Seed Farms and to over 5,000 farmers. In 1966-67 an additional 18,000 tons of seed was imported and planted on one million acres.

55. The program for seed production and distribution was modified in such a way as to give maximum production and early release to the farmers. In 1967-68 the National Seeds Corporation became involved in the multiplication of seed stocks of foundation and certified classes. In addition, this agency is increasing all promising selections prior to their formal release so that sizeable stocks of seed will be available for distribution. This will decrease the amount of time it takes to get a new variety to the grower. Such a procedure does present the problem of having to increase many selections which may be discarded without ever being released. The method of seed increase has worked well enough in India that no importation of seed stocks was necessary in 1968-69.

56. The first semi dwarf wheat varieties and selections were introduced into West Pakistan in 1964 by FAO for testing in micro plots. Results of these tests were so encouraging that in 1965 the Ford and Rockefeller Foundations assisted in introducing 350 tons of several semi dwarf varieties for additional trials and for multiplication. An additional 50 tons of a white kernel variety (Mexipak 66) was also introduced because of its more desirable milling and baking qualities. Dr. Ignacio Narvaez of the Rockefeller Foundation moved to Pakistan to assist in coordinating and providing technical assistance to the wheat program. In 1967-68 a further importation of 42,000 tons was made. Up until 1968 over three quarters of the seed of the new varieties was sold from farmer to farmer with government or commercial sales being almost

zero. In 1968 a large quantity of the variety Mexipak was purchased by the Agricultural Development Corporation, a quasi-government organization. The 50 tons of the whitekerneled Mexipak 66 imported in 1966 was kept under the control of the Department of Agriculture and was only released to farmers who agreed to seed the variety in 24 inch rows at a seeding rate of 20 pounds per acre.

57. The wheat program in Turkey was implemented by a group of progressive farmers who purchased 60 tons of the variety Sonora 64 in 1966. The results obtained looked so promising that the government officials imported 22,000 tons the following year. Of this 22,000 tons, 1,770 tons was purchased in Mexico as certified seed. This certified seed along with 400 tons of additional seed representing United States varieties was used by the State Seed Farms Directorate for seed increases. This was carried out largely through contracts with private growers. Those farmers requesting credit to purchase seed also had to buy sufficient fertilizer to insure an adequate seed increase. Plans for the distribution of the seed were developed prior to its arrival in Turkey and were adjusted from time to time to reflect changes in local situations regarding farmer demand and other relevant factors. Also the policy requiring that new varieties be tested continuously for three to five years before official release was changed.

58. The introduction of the semi dwarf varieties into Morocco was initiated by a series of research trials. As a result of these tests USAID financed and arranged for the importation of 500 tons of seed of five varieties for the 1968-69 crop season. This seed, along with 25 tons produced the previous year in Morocco, has been planted in all the

wheat growing areas with 90 percent concentrated in the better rainfall areas. Nearly 4,900 hectares have been planted on private farms selected by GOM and USAID technicians, in fields ranging from 10 to 100 hectares. The primary purpose is seed increase but equally important are the demonstration and training objectives which are also being realized both on dry lands and in irrigated sectors. Furthermore, a government policy requiring five years of testing prior to approval for certification was reduced with only two years being required for some of the new varieties.

59. In considering the massive inputs of seed and the problems of distribution it is remarkable that any country could manage such programs, particularly in such a short period of time. However, several important points become apparent. First that the local governments changed their policies on introducing new varieties and the length of time such varieties had to be tested before they could be released. That the governments played an active role in increasing the seed, which in many countries meant involving the private sector. Also some control was maintained as to how the seed was to be grown in order to obtain maximum production. Assistance was obtained from individuals who were familiar with the production of semi dwarf wheats under conditions similar to the local countries. These individuals were obtained from the various foundations, FAO or by USAID through university contracts. How effective the various certification agencies will be in maintaining the genetic purity of the new varieties can only be determined over a period of years. In most countries the seed increase and certification program looks quite good on paper, however, there are some indications that in practice problems have been encountered.

60. In some countries new seed laws are needed to insure physical and genetic purity, germination and proper labeling. Several countries are now developing standards which will be in compliance with the laws set by the Association of Official Seed Certifying Agencies (formerly known as the International Crop Improvement Association). In some countries a modified program involving the generation system is being employed to insure the genetic purity of the seed stocks. There is no question that this is an area where greater assistance is needed. However, it must be kept in mind that the first consideration of these programs was to increase the food supply. Developing an effective certification program should be considered as an important aspect of putting cereal production on sound footing to insure future success.
61. Along with the development of an effective certification agency some thought should be given to setting up suitable grades for the marketing of wheat. As the countries become more sophisticated in the types of wheat products they desire and the milling industry develops greater capabilities it will be necessary to set up standard grades so wheat can be marketed efficiently.
- C. Adaptive Research
62. There was a great deal of variation from country to country in regard to the amount of adaptive research conducted and the quality of the research prior to the large introductions of the new wheats.
63. In India and West Pakistan there were extensive trials conducted two years before any large introduction of seed. It was observed in India that Sonora 63 was quite susceptible to yellow rust and should not be imported. Lerma Rojo 64 on the other hand was late in maturity but had a high degree of resistance to all three major rusts. Sonora 64 was early

in maturity, was the most resistant to lodging and was well suited in rotations with maize, potatoes, rice and sugar cane. A further observation was that Sonora 64 did not do well when planted before the middle of November in areas where the normal sowing is late October or early November. Also this variety was found to be susceptible to yellow or stripe rust in several areas.

64. Similar information was obtained in West Pakistan, however, here in addition to determining how adaptive the new varieties might be, they also found that the farmers and the markets were reluctant to buy varieties with red kernels and/or which had poor milling qualities for the making of chapatis. Therefore, on the basis of quality considerations they imported Siete cerros or Mexipak 66 which is white and more acceptable by the farmers since it had the qualities desired by the local markets.
65. These are only a few of the findings which resulted from research conducted prior to the introductions of the new wheat varieties. The most significant factor is that some information was available to provide direction in determining which varieties to introduce and some indication as to the most suitable cultural practices to use.
66. The adaptive research programs conducted in Turkey prior to the major introduction of the new wheat varieties was essentially nonexistent. Many of the new wheat varieties had been tested, however, the experiments were carried out using the same package of cultural practices that had been used with local varieties. This meant, among other things, that little or no nitrogen fertilizer was used and as a consequence the new wheats did not perform any better than the local varieties. An experiment station at Adapazari tested the new varieties and had actually shown

their superior yielding ability, however, this information was not disseminated nor were satisfactory yield trials conducted throughout the coastal area where most of the new wheats were initially introduced. Information was available in 1966-67 from 102 farmer's fields which were the result of a group of farmers purchasing 60 tons of Sonora 64. These fields were located along the Mediterranean coast. The more progressive farmers modified their conventional cultural practices and applied some nitrogen to the wheat.

67. The experiences and research conducted in India and West Pakistan were also valuable in developing the program in Turkey. Also it is not surprising, based on the very limited amount of information that was available, that some of the Turkish research people should oppose the government's plan to introduce 22,000 tons of the new varieties the following year.
68. A series of experimental tests with the new wheat varieties were undertaken in 1966 in Morocco when USAID requested seed directly from CIMMYT. This material was tested at one location, with the exception that one variety Siete cerros, was grown at four locations. Additional varieties and selections along with various cultural practices were grown at several sites in 1967-68 and provided the basis for importing 500 tons of seed of five varieties for the 1968-69 crop season.
69. In Paraguay, Mexico and Colombia a considerable amount of adaptive research was undertaken with the development of the new wheat varieties. Therefore, when the new wheats were brought into commercial production information was available regarding the necessary cultural practices. However, there was a breakdown in getting such information to the farmers due to ineffective Extension involvement.

70. When considering the amount of information that was available regarding the performance of the semi dwarf wheats under conditions in the local countries, the following factors are important. The wheat yield of the local varieties was quite low and many of these varieties were susceptible to the local diseases. In several countries some effort was underway to improve the cultural practices with the local wheats and yield increases were realized. The countries recognized the need for providing the necessary inputs of fertilizer and irrigation in drier areas along with the improved seed. In addition, the new wheats were planted on the better lands and often with irrigation which minimized the chances of failures. People who had a considerable amount of experience with the growing of semi dwarf wheat in other parts of the world were brought in to evaluate the potential and make recommendations prior to the large introductions. These people were supported by the foundations and by USAID contracts with U.S. universities.

71. However, the importance of adequately testing new varieties under the growing conditions of a specific country cannot be underestimated. If a new wheat program is to have a reasonable chance of success adaptive type research must be the first step. A good example of why the first step should involve some adaptive research can be found in Turkey. The first major introduction was of the variety Sonora 64 which happens to be very susceptible to the local races of stripe rust. Fortunately in 1966 when this introduction was made the disease did not develop until quite late and never became a serious problem. However, since this first introduction of Sonora 64 had a major impact on the decision of the Turkish government to initiate a new wheat program, if the disease had developed as it usually does, the wheat program in

Turkey could have been set back many years. Future programs should keep this type of situation in mind in deciding on a course of action which does not consider the importance of adaptive research as being the first step.

D. Interrelationships of Institutions

72. Once the decision was made to undertake a wheat program most governments recognized that if maximum yields were to be obtained that the adaptive research effort would have to be increased. Furthermore, that if productive results were to be gained a reorganization of the many research agencies would have to be made so that there would be a greater coordinated effort and better lines of communication developed for the dissemination of information. In most countries reviewed both short and long term projects have been developed which include research on both cultural practices and varietal development.
73. In many countries this is a major step forward. In the past many research agencies were essentially independent, an independence which in some cases was jealously held to without any means or desire to share research findings. However, there is no question that a great deal more effort needs to be extended in this area if effective and meaningful programs are to be carried out.
74. In Mexico the research program was originally conducted by the Rockefeller Foundation which has now joined with the Ford Foundation to establish the International Maize and Wheat Improvement Center in Chapingo, Mexico. Currently cooperative research programs are carried out with the Mexican government. The important land marks noted by Stakman et al. in the development of the program indicated: (1) that Mexican investigators provided Mexican Extension agents with information

gained from their investigations, (2) field days were held where young Mexican scientists reviewed their work in such a manner that Mexican farmers could understand, (3) official seminars were held where local scientists could present papers, discuss results and plan future programs, (4) development of a postgraduate college of the National School of Agriculture for the training of future scientists.

75. A major change in India regarding research was the development of the All India Coordinated Wheat Improvement Scheme. Prior to this new program the research effort had been conducted by the State and Centre Institutions. Perhaps the biggest disadvantage was that there was no annual meeting where the wheat workers could get together and discuss their results and jointly plan productive programs. As a result of the All India Coordinated Wheat Improvement Scheme, a systematic testing program has been established with locations at nine main centers and nine subcenters which are located in the major wheat producing areas. In addition to determining adaptability of promising new selections, this agency also has the responsibility of determining what are the best package of cultural practices to give maximum yields. Experiments are being conducted on such factors as the depth of sowing, level of nitrogen, critical times of irrigation, rate, date and spacing of planting, methods of applying fertilizer as well as other aspects of wheat production. There is also a growing proportion of the research effort being assumed by the developing agricultural universities.

76. The yield breakthrough in wheat yields in West Pakistan has brought about a growing demand for research programs to find better agronomic practices and to develop varieties with better milling qualities. The concern for better trained research personnel has also been noted with

USAID and the Ford Foundation being asked to support more participants for foreign training at the various agricultural research stations and universities.

77. Along with the decisions to introduce the new wheat varieties the Ministry officials in Turkey recognized the importance of agronomic research and, under the direction of the Minister of Agriculture, completely reorganized wheat research. As a consequence a coordinated research program is now underway with many excellent investigations currently in progress, particularly on cultural practices. The varietal development for the coastal areas does not seem to be progressing, possibly due to the hope that the Rockefeller Foundation may establish a plant breeding center in Turkey.
78. The research programs in Morocco are the responsibility of the Agronomic Research Division of the Ministry of Agriculture, which was formerly a semi autonomous institute. One of the major problems in the programs is that many of the staff are non-Moroccan professionals which, because of uncertainties of contract continuation, are reluctant to undertake long-term research objectives. Replacement by Moroccan technicians is very slow because of insufficient numbers of qualified personnel. To date most of the wheat improvement research has been conducted under moderate to low fertility levels and often with inadequate moisture levels. Two other problem areas are that the work is conducted exclusively on experiment stations and the research staff has very little contact with Extension activities.
79. It is interesting to contrast the above mentioned programs with the research being conducted in Colombia where a sound and successful experimental program has been in existence for a number of years.

The Colombian Agricultural Institute which has been assisted by the Rockefeller Foundation has been responsible for the development and release to farmers of more than a dozen improved wheat varieties. The impact of the new varieties has reached practically all the wheat farmers in Colombia; however, wheat has remained a minor crop in terms of acreage cultivated. Several factors have contributed to this situation. The beer industry has been much more effective in promoting barley which competes for the same land as wheat and farmers do not regard wheat as an indispensable food item since many substitutes are available. Perhaps one of the most limiting factors has been the institutional efforts, particularly that of the Extension Service, which have not been effective. The recent increase in wheat production is due in part to the government maintaining a price policy and if the other institutions develop, such as the Extension Service, wheat production will continue to increase. In Colombia all institutions were not working together and as a result of a weak link the production work of one institution was not being utilized.

80. A major spin off of the new wheat programs has been the impact it has had on the Extension Services within the countries. In one report the point was made that prior to the introduction of semi dwarf wheat varieties the county agents had nothing to extend. Furthermore, even if they did have some information no vehicles were available for them to travel to the farms and if they could, most of the farmers would not believe them anyway. The wheat program has turned out to be the mechanism in developing the proper role of the county agents.
81. It is ironical, however, that in Mexico where the first benefits of these wheats were obtained the educational programs at the farm level have been lacking. The result has been that the large, progressive farmers

were able to take advantage of the new varieties without an educational input by the government, with the smaller farmers being largely neglected. The question which must be asked, however, is this. Is the objective to increase food supply as fast as possible or to help the small farmer?

82. Until the coming of the "green revolution" the Indian Extension agent did not have much technology to extend. However, with the new wheats the Extension agent was introduced an awesome challenge since a single village level worker may have to cover up to ten villages and up to 5,000 farmers. Once the wheat program was undertaken it became a problem of not having sufficient personnel. If the Extension Service is to become more effective nearly 60,000 block level workers and nearly 50,000 other staff members need to be retrained in the new technology. There is an attempt to recruit new people from the agricultural university graduates. Training in the future will stress production and technical skills.

83. A similar story can be told for West Pakistan where the food grain breakthrough has resulted in greater status for the Extension Service. With the farmers having to change from their traditional farming methods to the new technology they had to have new information. The only persons with reliable information on seeding rates, planting dates, fertilizer requirements, timing of water application, etc. were the Extension workers. This in turn has built up the Extension worker's desire and need for information. As a result, training courses of a practical nature were initiated in all parts of the country. The technical level of knowledge required for advising farmers has made the government aware of the insufficient training of their field assistants in the Extension Service, therefore, they have initiated a project to

replace those workers who have a maximum of 10 years schooling with university agricultural trained graduates. USAID has agreed to assist the government with technical assistance and guidance to get the new project underway.

84. Turkey's Agricultural Extension Service has 1,800 staff members in addition to other segments of the government who have people stationed in the rural areas to work with the farmers. When it was decided that 22,000 tons of the new wheats were to be introduced, it was the Extension Service who supplied the principal force in implementing the promotional program to make sure that the new wheats were used successfully by the farmers. It was also their responsibility to see that the seed and fertilizer were properly distributed. For example, the Extension Service assigned approximately 250 staff to work specifically on the wheat program; it authorized the use of extra automobiles for transportation; it authorized extra per-diem payments; it spent extra money for posters, brochures and other training aids; conducted seminars and training meetings for its own workers as well as for farmers. It also coordinated its activities with other agencies.

85. A major input of the Turkey program was the contract with USAID and Oregon State University to provide 12 county agents and farmers to assist with the Extension activity. These individuals were sent to the various wheat producing areas and worked directly with the Turkish county agents. They were involved in a large number of meetings with Extension personnel at the village level. They helped in developing and disseminating information and in general acted as catalyst to the Turkish Extension Service. When a vehicle shortage was pointed out by this group the Inter-Ministerial Council provided the necessary vehicles and drivers

from other agencies. As one Extension director pointed out, he had been to more village meetings during the first year of the new wheat program than he had attended during all of his previous Extension years. This input of American county agents and farmers was extremely important in teaching their Turkish counterparts how to get a job done. One additional factor should be stressed and that is that three members of this team were farmers from the Pacific Northwest. They were extremely effective in communicating with the Turkish farmers. When they pointed out how they carried out similar operations on their own farms the Turkish farmer became convinced that it must be the right way. In future programs this might be again used as a very effective input.

86. The National Extension Service in Morocco lacks an adequate specialist staff for in-service training and technical backstopping of agents and for the preparation of technical materials. Thus, Extension agents are often poorly trained, poorly informed or lack proper Extension materials and cannot conduct adequate farmer training programs. This appears to be a major limiting factor in the introduction of the new wheat varieties. A program involving United States county agents and farmers might be one input the Morocco wheat program may wish to consider. As noted in an earlier section of this report, Colombia also has a similar problem.

87. There is no question that one of the most far reaching impacts the new wheat programs will have is that now for the first time in many countries the various institutions are working together to reach a common goal. It has been and will continue to be a learning experience in how to solve problems by various government agencies and the private sector. With the development and introduction of the new wheats every segment of agriculture had an opportunity to contribute to the success of

the program. When one segment did not wish to participate or did not have the technical competence, the whole program suffered. It is much like the package concept the farmers must adopt if they are going to get maximum yields. All the various institutions can be considered as a package, each complementing the other and if a program is to be successful each institution must play its role. In Colombia the research institution was very able and had released superior varieties, however, this had no benefit due to the lack of inputs by the other segments. The new wheat varieties can be looked on as a vehicle which brought together many segments of the agricultural sector and this well might be a greater contribution to the future welfare of the less developed countries than the fact that wheat production was increased. Future programs of assistance must be so developed to complement the total program so that each segment, be it banking, research, extension, marketing, etc. must be in a position to contribute.

E. Promotion of the Program

88. The point was developed earlier that the main reason for success in many countries was the involvement by the government officials in selling the program to their people. However, in Mexico little or no effort to promote the new wheats was made by the government. Even though the wheat program must be considered a success in terms of increased production the fact remains that a very large segment of the rural population have not benefited from the technological progress. For example, it is estimated that 90 percent of the new wheat varieties are grown under irrigation which involves only about 15 percent of the farmers in the country. It was pointed out in the Mexico report that information regarding the new wheats and the improved cultural practices which must be used was passed

by word of mouth among the more progressive farmers while the less able farmers were neglected.

89. This is in direct contrast with the program in Turkey where a vigorous and far-reaching educational program was undertaken by the Ministry of Agriculture to instruct all farmers in the cultural methods to be used with the new wheats. A cookbook for growing new wheats was developed and distributed by the county agents to the farmers. Educational materials such as flip charts were developed and used by the county agents in farmer meetings. The American county agents and farmers assisted in helping local county agents in becoming effective in directing educational meetings and by their very presence added to the prestige of not only the local county agent but to the whole wheat program. In addition, training sessions were held with the Extension and state farm leaders who in turn held meetings with their staff and the information was then taken to the villages. Also each farmer was given a card to record various types of data during the growing season. This not only provided some information but instilled in the farmer a sense of contributing to the overall success of the program.
90. In countries like West Pakistan programs were started such as one called "Grow More Food." The radio was also a significant item for promotion and education. As a result of direct orders from the President of Pakistan a daily fifteen minute program during prime time informing farmers of the new wheat program and the new cultural practices was broadcast.
91. One of the most effective promotional factors was the use of demonstration plots, particularly on farmer's fields. Most farmers seeing what could be done with the improved seed and the package of cultural

practices on fields similar to theirs were convinced of the soundness of the program.

92. Also that the governments indicated their sincere interest by aiding in the development of irrigation facilities, making fertilizer, pesticides and seed available at reasonable costs was encouraging to the farmers. The government's involvement in price support programs and in making credit available further convinced the farmers that this was a worthwhile program.

VII. ROLE OF THE FARMER

93. Farmers are the same the world over and if they can be shown that new farming systems will be beneficial they will quickly adopt them and many times will improve upon them. The actual involvement of the farmers in the new wheat programs varies from their purchasing the initial large importation of seed, as in Turkey, to financing yield trials in West Pakistan. It is easy to forget that if it was not for the individual farmer's willingness to try something new these programs would not have gotten off the ground. This is particularly true when it is realized that many of these farmers must obtain a crop every year or their welfare will be jeopardized. Even though in many countries the richer, more progressive, farmers participated it is also true that many farmers went deeply into debt to become a part of the programs.

VIII ROLE OF THE PRIVATE SECTOR

94. The development of the private segment in agriculture as a result of the new wheat varieties may play a very important role in the future economy of the less developed countries.
95. In Mexico there is very little indication of an active role being played by the private segment other than the increasing of seed of new varieties. In this area they have been much more efficient than the government organizations.

96. The government of Pakistan changed its policy when the public sector proved to be inefficient in keeping up with the increased demands for fertilizer. Private enterprise now has the major responsibility for distribution, sales and promotion of fertilizer. There has also been considerable activity in the private section in developing tubewells.
97. The government of India appears to have dominated all phases of the new wheat program. Even though the private section is involved in seed multiplication, fertilizer distribution and some equipment manufacturing it has not developed greatly as the result of the new wheat program.
98. The greatest growth in Turkey due to the new wheat program has been in the manufacture of equipment. This is regarded as assuming very important proportions in Turkey's future.
99. As Morocco initiates the new wheat program considerable interest has been stimulated by the private sector, particularly in the seed multiplication phase of the program.
100. It would appear that as the new wheat programs become more fully developed, the private sector offers a tremendous potential not only for more effective production but also in stimulating related segments of the economy. Also, if in future years governments turn their attention away from the wheat program toward other problem areas, there could be a reduction in the effectiveness of the program. If the private segment can be sufficiently developed then a firmer foundation will be laid and future progress maintained without further major inputs by the governments.

IX. ROLE OF USAID

101. Although USAID did not contribute directly to the development of the new semi dwarf wheat varieties, they did play a significant role in the introduction of new varieties and the subsequent expansion of wheat production in several of the less developed countries. This paper will

not identify the various inputs that the agency has made for each country. Instead an attempt will be made to determine the impact which long-sustained programs have had in assisting countries to adopt the new wheat programs. In addition, some consideration will be given to the more immediate role played by USAID in helping to implement the so called "green revolution."

102. As a result of programs in institution building, it becomes quite clear that in countries where the wheat programs have been successful, a nucleus of trained people were available. Many of these people received their technical competence as a direct result of participant training programs financed by USAID. It was this reservoir of technicians in the local countries who came forward and provided the necessary leadership within the various institutions that contributed materially to the success of the programs. The efforts of USAID to influence policy changes and provide direction made it possible for the various institutions to work together at the appropriate time in attaining the desired objectives. When it became clear that various institutions needed reorganization USAID provided the necessary guidance and assistance in making effective changes. In countries where the wheat programs have not been successful a part of the problem can be traced to a breakdown in the proper function of one or more of the institutions. The weak link often times was the Extension Service or a government policy which did not allow for a farmer to realize a just return on his investment. Also survey teams contracted by USAID played an important role in evaluating agricultural programs and determining the necessary resources needed if new programs were to be effective. Many times such teams instilled a confidence in the local government so that they moved ahead in the program.

103. At the farm level USAID has assisted in working out policies so that increased crop production was profitable. This included such items as making credit available, insuring adequate markets, teaching improved cultural practices and stimulating the private sector to play a more active role.
104. The specific function of USAID in assisting the actual introduction of the new wheats varied from country to country. In West Pakistan and India, for example, USAID complemented the efforts of organizations such as the Ford and Rockefeller Foundations and FAO. In Turkey, USAID was involved in all phases of the wheat program. This included planning much of the overall strategy in cooperation with the Turkish government.
105. A number of major actions resulted from this close association and illustrate the types of programs in which USAID became involved within several countries. These included: (1) encouragement and guidance in policy-making decisions at each step in the program, including such things as selection of fields in Mexico for sources of seed and insuring that markets would be available at harvest time; (2) providing technical assistance by U.S. technicians to evaluate and make recommendations regarding the necessary cultural practices; (3) massive farmer education programs; (4) stateside training of key Turkish officials; (5) provision of required fertilizer; (6) provision of credit; (7) development of a more effective extension system by bringing U.S. county agents and farmers in to assist; and (8) aiding in developing an effective system of adaptive research.
106. A great deal has been written regarding the value of short term consultants in international programs. The general conclusion has been that if productive programs are to be developed they must be undertaken

by people who are willing to commit themselves for long periods of time. There does not appear to be any question that for many types of programs long term assignments are absolutely necessary, however, the program in Turkey has also shown that the short term assignment can also have a real impact in terms of helping to implement programs. Short term assignments by individuals with special expertise can provide a degree of competency which could greatly benefit the local governments as well as USAID personnel who cannot hope to be specialists in all fields of agriculture. A good example of the benefits which can be derived from short term assignments is the impact the U.S. county agents and farmers had in upgrading the Turkey Extension Service. It would appear that it is the type of program which should determine the duration of the assignment and that there is a place for both short and long term tours.

107. In the final analysis, the contributions made by USAID in extending the new wheat programs to less developed countries can be summarized in the following manner. As a result of long term projects, such as those involving institutional building, USAID provided the necessary groundwork which enabled some less developed countries to capitalize on a technological breakthrough, namely the development of new high yielding wheat varieties. Once the programs were initiated, USAID played an important part in helping local governments develop a strategy based on previous USAID inputs that were the products of long range projects. Also, more immediate needs were met, such as the purchase of seed and fertilizer, or providing the necessary technical assistance. The role played by USAID was essentially one of fact finding and problem solving.

108. When limiting factors were noted the necessary physical, economical and management inputs were made and in such a manner to insure the success

of not only the wheat program, but future developments in the agricultural sector. If there is one common factor found throughout those countries where USAID has made a major contribution it would be in developing a balance between the various institutions so that each could play an effective role. In countries where this balance has not been achieved and the necessary institutions were not involved, the wheat programs are developing at a much slower rate.

109. In considering future programs several points should be noted. Since local governments were so closely involved with the wheat programs it would appear desirable to encourage a greater participation from the private sector. This could involve such activities as the multiplication of seed, making fertilizers and pesticides available and in the manufacturing of equipment. If this segment could be more fully developed it would add a greater stability to not only the wheat programs but to all phases of agriculture production.
110. Greater effort will also be needed to develop more efficiency in the farming operation and to avoid any possible complacency that might result when self-sufficiency is attained. This is particularly true when the secondary problems arise from both the agronomic and economic standpoint.
111. As these countries approach self-sufficiency in wheat production plans should be made to move toward a more balanced agriculture. In many of these countries there are large dryland areas where it is not possible to irrigate. A very large percentage of this land could produce satisfactory wheat yields if suitable moisture conserving practices are employed. This would allow for a greater diversity in the types of crops which could be grown on the irrigated lands. Such things as vegetable and specialty crops along with improved pastures could be grown on these lands.

X. SUMMARY

112. This paper represents a global report on the development and introduction of semi dwarf wheat varieties into seven countries. Major importance has been placed on the agronomic inputs that were necessary in carrying out the program. In addition, the role played by the local governments, the private sector, farmers and USAID was examined in light of their participation. No attempt was made to evaluate the relative contributions made by the foundations and other organizations who were also involved in the wheat programs.
113. The countries reviewed were India, West Pakistan, Turkey, Morocco, Paraguay, Colombia and Mexico. Emphasis was placed on those countries where large introductions of the new wheats were made. The countries mentioned provided a number of meaningful comparisons since they differ in the length of time the wheat programs were in existence and how the programs were implemented. Also, due to numerous factors, there were differences as to how successful the programs were. Factors which contributed to the success or lack of success are outlined in this report.
114. Wheat production prior to the development of semi dwarf wheats was similar in many countries. Total production was entirely dependent on the climatic conditions which prevailed during the growing season. This resulted in large fluctuations in production which had a very adverse effect on all segments of agriculture and the countries as a whole. There was some evidence that, through the use of improved cultural practices, countries like India and Turkey had increased their production of local wheats. However, with expanding populations and apparent reductions in U.S. grain supplies, a serious problem had developed.

115. With the introduction of the semi dwarf wheats it has been possible to obtain yield levels which are, on the average, twice that of the local varieties when grown under similar conditions. Where ideal growing conditions were encountered and with proper cultural practices, yield levels in excess of 6,000 pounds per acre were reported. However, the need for adaptive research within the local countries is pointed out by the relatively low average yields which have been obtained with the semi dwarf wheats, particularly when irrigated. Wheat acreages in these countries has remained the same the last few years, except in India where a substantial increase can be noted. Increased production is expected to result from the higher yields per acre which can be obtained with the new wheats. This assumption is supported by the experience gained in Mexico.
116. As a result of preliminary yield data, several of the countries are expected to reach self-sufficiency within the next few years. In Morocco, however, even with the new technology there is some question as to whether production will ever equal the demand.
117. The agronomic input which has received the greatest attention is the development of the new stiff strawed semi dwarf wheat varieties. With the addition of the photoperiod insensitive reaction, the semi dwarf varieties developed by Dr. Borlaug and his group have a very wide adaptation. This has made it possible to successfully introduce this germ plasm into many different environments.
118. In considering a wheat improvement program with the new varieties, it is very important that the package concept be understood. That is, unless the proper cultural practices accompany the new wheats they will not respond any differently than the local varieties in terms of yielding ability.

The correct cultural practices includes such factors as proper seed bed preparation, use of adequate amounts and types of fertilizer, irrigation if rainfall is not sufficient during the growing season, use of pesticides and suitable equipment.

119. The necessary input of fertilizer and particularly nitrogen to obtain high yields was well accepted by all the countries. In some cases, as in West Pakistan, drastic changes were made in the method of distribution with the private sector becoming involved. Turkey experienced some difficulty in obtaining sufficient nitrogen fertilizer this year and, as a result, yield levels will be lower. Also in some countries farmers are tending to use less than the recommended rates.
120. As noted in the report from Mexico, the life blood of the improved varieties is provided by water. In Mexico and more recently in West Pakistan and India, a dramatic increase in the amount of irrigated land has occurred. In the latter two countries this has been largely due to privately financed tubewells. To date, the amount of irrigated land available has not been a limiting factor to the introduction of the new wheats. Adequate rainfall is received during the growing season in Turkey, Paraguay and Colombia, so irrigation is not as important a factor. In Morocco, the wheat program is just starting and the role of irrigation has not been fully assessed. High yields have been reported where irrigation has been used in experimental plots.
121. In many countries the need for suitable equipment was a major limiting factor. The local governments have recognized this deficiency and are developing programs to overcome the problem. In Turkey, the private segment is playing an increasingly important role in this area.

122. Very few pesticides are used on wheat, with the exception of 2,4-D. It must be emphasized that many of the secondary problems resulting from the new cultural practices will require a greater dependence on the use of pesticides in the future.
123. Many factors can be cited that contributed to the decision of the local governments to undertake a wheat improvement program. Some of these were the realization of the potential breakthrough the new wheats held for their country, changes in U.S. foreign policy and many less obvious internal factors within the respective governments. The factor which played a dominant role in the success of the respective wheat programs was the degree of commitment made by the governments. This included, among other things, sufficient pressure from top government officials on the various institutions to work together in a coordinated effort. Also, the willingness of governments to change longstanding policies if they interfered with the wheat program. These changes in policy varied from adjusting the support prices and making credit more available, to completely reorganizing some of the institutions. When considering the massive programs which were undertaken in such a very brief period of time, the role of the local governments cannot be overestimated.
124. The new wheat varieties were introduced into the various countries under many different circumstances. In West Pakistan and India limited quantities of several varieties were introduced and tested prior to the large introductions; while the program in Turkey was implemented with little or no information regarding which varieties were best adapted. However, the performance of the local varieties was so low it did not take a great deal to surpass their yielding ability. Fortunately, the new varieties had a sufficiently wide adaptation that very few problems were encountered.

125. In several countries changes were made in the certification laws reducing the number of years that it was necessary to test new varieties before they could be released to farmers. Also, certain prerequisites were made so that when a farmer obtained the seed he would get a maximum increase of the limited seed stocks. In Turkey if a farmer borrowed money to buy the new seed he also had to purchase the necessary amount of fertilizer. With the increasing number of varieties it will be necessary for the local governments to develop a workable system of multiplying new varieties. Such a system should comply with the laws set forth by the Association of Official Seed Certifying Agencies.
126. One of the major impacts the wheat program has had is in forcing the many research units to work together toward a common goal. This includes sharing of research results at annual meetings and planning meaningful future research programs. A coordinated effort as a result of the wheat program could prove extremely important to the success of future programs in agriculture.
127. A weakness which consistently showed up in the various countries was the Extension Service. As was pointed out in several reports, prior to the introduction of the semi dwarf wheats the county Extension agent had nothing to extend. The wheat program provided the necessary reorganization and gave the Extension Service a new image. A very effective input in Turkey involved providing 12 U.S. county agents and farmers who helped in developing and disseminating information and, in general, acted as a catalyst for the Turkish Extension Service.
128. There was a great deal of variation in the promotional activities conducted by the local governments. In Mexico, the government did not promote the new wheat program extensively. As a result, the more

progressive farmers got the information by word of mouth, while a very large segment of the rural population did not benefit directly from the new technology. In other countries, like West Pakistan, the President ordered that a fifteen minute program be presented daily during prime time. Certainly one of the most effective promotional activities was the use of demonstration plots, particularly when they were located on farmer's fields.

129. The farmers in these countries are typical of farmers everywhere in that when shown new ways of doing things they will take up the new system quickly, providing they can see a just return on their investment. In the wheat program farmers were involved in such activities as purchasing the first quantities of the improved seed to financing yield trials. There is no question that their interest brought pressure to bear on many government officials and aided in the decision to undertake the new wheat program.

130. Private enterprise is just now developing in many of these countries and there are a number of examples where they have played a very effective role. One example would be in distributing the necessary fertilizer in Pakistan. There is some evidence that the private sector in a number of countries is becoming interested in such activities as seed multiplication, fertilizer and pesticide distribution and the manufacturing of equipment. This is a very important part of the total agricultural program and needs to be strengthened.

131. Although USAID did not contribute directly to the development of the semi dwarf wheat varieties, they did play a significant role in the introduction of the new varieties and the subsequent expansion of wheat production in several of the less developed countries. As a result of USAID's long term projects involving such things as institutional building, the

the necessary groundwork was provided which enabled these countries to capitalize on a technological breakthrough. Once the wheat programs were initiated USAID played an important part in helping local governments develop a strategy based on previous USAID inputs that were the products of long range projects. Also, more immediate needs were met, such as providing money for credit through the Agricultural Banks, purchasing seed and fertilizer and providing the necessary technical assistance. The role played by USAID was essentially one of fact finding and problem solving. When limiting factors were noted the necessary physical, economic and management inputs were made and in such a manner not only to insure the success of the wheat program, but future programs in the agricultural sector as well.

132. In considering future programs, several points should be noted. The first would be to encourage a greater involvement of the private sector. This would provide more permanency in the programs since a larger part of the total economy would be involved and not just the government.
133. Also, greater emphasis needs to be placed on efficiency in farming to avoid any possible tendency to become complacent once self-sufficiency is reached in wheat production. Plans should now be made toward developing a more balanced agriculture in these countries. For example, there are large areas with low rainfall where irrigation is not feasible but which are suitable for wheat production, providing proper summer fallowing practices are employed. This would allow the irrigated lands to be devoted to the growing of other crops such as vegetables or perhaps pastures and hay for a livestock industry. Such a program would allow for a more effective use of the land.

134. It would appear that there is a greater need for such organizations as the Ford and Rockefeller Foundations, FAO and USAID to develop a greater degree of cooperation so that the role played by each could complement the total effort in a more effective way.

135. The question is frequently raised as to the value of short term consultants in international programs. The wheat programs pointed out rather clearly that there is a need for short term people who can provide special expertise for solving specific problems. This is particularly true when a number of visits are involved to check on the progress of the programs. There is no question that where long range projects are involved, like institution building, it is necessary to have people who are devoting their professional career to international agriculture to provide the necessary continuity.