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9. ABSTRACT
A close look at the adoption of the new wheat technology, emphasizing high yielding seeds and chemical fertilizers. The study's specific objectives were to see to what extent farmers have adopted the new wheat seeds, applied chemical fertilizers to wheat, and followed other agronomic practices recommended to them; to identify and quantify association among adoption of high-yield varieties and fertilizer and selected factors related to the farmer, the farm and government policy; and to examine the extension system, credit and input supply situation, and market conditions as they relate to the adoption of new wheat technology. To carry out these objectives the study draws heavily on data obtained through regional samples consisting of 800 farms with different characteristics. Among the conclusions are that there are many gains from the new wheat technology from which the country can benefit, and thus research must be given priority in the overall efforts by the state. To achieve the maximum yield potential from the new seeds, timely and proper seeding is necessary and the farmer should be supplied always with certified seeds of reliable quality. Farmers' membership in an agricultural organization has been found to increase new seed adoption and fertilizer use. Simple calculations indicate that if all traditional varieties are replaced by high-yield varieties and if a modest yield level of 2 to 2.5 tons can be reached, then the three coastal regions alone would supply almost one-third of the nation's needs from the existing amount of land.

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THE ADOPTION OF NEW BREAD WHEAT TECHNOLOGY IN SELECTED REGIONS OF TURKEY

Edited and abridged by CIMMYT

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CONTENTS

Foreword v

I. Setting the scene in Turkey 1
Sources of production 1
Coastal spring wheat programs 2
Review of subsequent chapters 3

II. Farm and farmer characteristics in the regions studied 3
Sampling strategy 5
Regional characteristics from survey data 7

III. Farmer incentives for adoption of recommendations 8
Measures of profitability of recommended procedures 8
Measures of risks of recommended procedures 10
Summary 11

IV. Adoption and characteristics of the farm, farmer, and government programs 12
HYV's and individual variables 12
Fertilizer and individual varieties 16
Other elements of the technology 18

V. Multivariate analysis of factors affecting adoption 19
Factors affecting adoption of HYV's 20
Factors affecting application of fertilizers 23

IV. Summary of findings and policy implications of the study 25
Findings 25
Policy implications 26

FOREWORD:ON LAUNCHING THE STUDIES AND MOTIVATING HYPOTHESES

Launching the Studies

The study described in the following chapters is one of a series aimed at enlarging understanding of the factors impinging on the adoption of new maize and wheat technology. Better understanding of the elements shaping the diffusion of new cereals technology can help governments and development assistance agencies to increase farmer income, hence the interest in the topic. Interest increased as controversy about effects of introducing new technologies attracted widespread attention to the theme.

CIMMYT, with its mandate defining its role in the development and diffusion of maize and wheat technology, quickly assumed a participant's role in the discussions. The concern and the interest emanating from the critical importance of the theme stimulated CIMMYT to look for a modus operandi through which patterns of adoption and the forces shaping those patterns could be identified. Better understanding of these relationships would influence CIMMYT efforts to develop new technology, the orientation of its training program, and the approach taken in counseling governments about national programs.

In order to better comprehend what influences farmer response to new technology, CIMMYT set out to facilitate the research on which this and the other studies of the series are based. We decided to examine eight cases in which maize or wheat technology had been introduced to farmers. In identifying programs for study, we limited consideration to those in which the technology had been available to farmers for no less than five years and in which no less than 100,000 hectares of land might have been affected. Eight programs were selected for study. For maize the focus was on Colombia, El Salvador, Kenya west of Rift Valley, and Mexico's Plan Puebla. For wheat, programs in India, Iran, Tunisia and Turkey were considered. CIMMYT's maize and wheat staff participated in the selection of these programs. With their knowledge of programs around the world it was possible to choose a varied set of experiences - e.g. programs with and without irrigation, with and without effective price guarantees, with massive extension effort and with virtually none.

To the extent possible, each of the adoption studies was under the supervision of an indigenous economist. In only one case was it necessary to turn to an expatriate and there we had the good fortune to collaborate with a researcher with several years experience in the area. Each of the collaborators shared CIMMYT's concern for farmer response to new technology.

Beyond sharing this concern, each collaborator had an interest in farm level research done in close cooperation with agricultural scientists. The importance of this interest emerges from our conviction that agricultural scientists who are knowledgeable about a particular maize or wheat area can contribute substantively to research on the cereals economy of that area. Their special knowledge about the interaction between plants and their environments is important in identifying agro-climatic zones, critical periods for the crop, and activities which are essential to effective cultivation. Many agricultural scientists played a prominent role in these studies; each warrants our gratitude for his contribution.

As the studies were completed it became apparent that much could be said for publishing them in a standard format. With several serving as Ph.D. dissertations and others as less formal research pieces, a common format could only be achieved through reworking the original monographs. In every case but one, then, CIMMYT's publication is an abridgement of a longer piece. The Indian study, itself a review of the findings of several other research efforts, is being published in its entirely with no effort to recast it in the form of the others.

In making the abridgement we have followed certain norms. Mathematical proofs have been eliminated, literature reviews have been included only where they relate to points which are unique to a given study, and the discussion of the hypotheses motivating the studies have been dropped. This last decision arises from recognition of the substantial commonality of these hypotheses among the studies. This suggested that, rather than presenting essentially the same discussion in the text of each abridgement, the hypotheses could be treated once in an abbreviated form for all studies. That treatment follows below.

The Hypotheses

While each of the studies examines a somewhat different set of circumstances, all depart from the same general assumption about farmer behavior. The assumption is that farmers are income-seeking risk averters who are sensitive to the nuances of the environment in which they farm and that they are generally effective in their decision making. For the six studies based on original survey data and to a more limited extent for the study of Plan Puebla, this common point of departure leads to a great deal of similarity in the motivating hypotheses.

Given a farmer oriented by the assumptions described above, we might expect to see relationship between the adoption of elements of the new technology and 1) characteristics of the farmer—his age, education, family size, farming experience, off-farm work, percentage of land owned, 2) characteristics of the farm—its agro-climatic region, competition of industrial crops, relative importance of cereals, nearness to markets, farm size, 3) characteristics of government programs—access to credit, access to information (though extension agent visits or visits to demonstration plots).

Some of the relationships between these variables and the adoption of elements of the new technology are more arguable, some less. Least arguable are hypotheses relating adoption to education, farming experiences, percentage of land owned, more favored climatic regions, relative importance of cereals, nearness to markets, farm size, access to credit, and access to information. With other things equal and accepting our assumptions that farmers are income-seeking, risk-averting, sensitive, and effective maximizers, virtually no one would argue that any one of these relationships should be negative.

Somewhat more arguable is the relation of age and family size to adoption. Even here it is likely that only a few would argue that these relationships might be positive.

Most arguable are the relationships linking adoption to off-farm work and competition of industrial crops. With respect to the former, some hold that the relationship is positive as more off-farm work implies more income, therefore a greater capacity to bear risk, hence a greater willingness to adopt new technologies. Others hold the converse, arguing that more off-farm work implies less interest in the farm, hence less willingness to put in the time and energy associated with taking on new technologies. So too for industrial commodities, where those who see the relationship as positive allude to greater experience with improved inputs and larger incomes while the contrary view rests on capital restrictions and the high opportunity cost of labor.

With knowledge of the relationships among these variables, researchers and policy makers can better develop and diffuse new technologies. Some of the variables considered, e.g. age and family size, are beyond the control of these decision makers. Nonetheless, by incorporating them in the analysis the effects of variables subject to their control are more clearly discerned. Knowledge of how these variables, e.g. agro-climatic zones and extension programs, relate to adoption can be of critical importance in affecting the development and diffusion of new technology.

With this rough sketch of the general argument, readers wanting more detail about the derivation of the hypothesized relationships can turn to the relevant original piece from which this series of abridgements was drawn. In all cases the studies feature the effects of agro-climatic region and farm size on adoption of elements of new technology. This emphasis is related to the earlier controversy about the effects of new technology where these two factors played prominent roles.

Before moving to the abridgement, some attention to the phrase "elements of the new technology" is warranted. Much has been made of the concept of a package of practices in the introduction of new technology. We've chosen to look at this a bit differently, taking the view that the differences in risk, expected income, and cost of each element of the technology are large enough to outweigh the effects of the interaction among these elements. That is to say, perceptive and prudent decision makers might well choose to take up only a part of the package rather than the entire package. For the programs studied, the two dominant elements in the package are improved seed and fertilizer. These two were analyzed as dependent variables in each of the studies. Of lesser importance are such elements as seed treatment, date of planting, method of planting, use of herbicides, use of pesticides, planting density, and seed bed preparation. Nevertheless, where any of these was recommended and where data are adequate, these are also treated as dependent variables.

While CIMMYT has been associated with these studies since their inception, the opinions expressed by the authors are not necessarily endorsed by CIMMYT.

What follows

This report summarizes results of a study of wheat technology in Turkey's coastal areas. The study is based on a survey of over 800 wheat farmers conducted in early 1973. That survey was a part of a larger effort under the direction of Dr. Resat Aktan and supported by Turkey's Ministry of Agriculture, the State Institute of Statistics and CIMMYT. Dr. Aktan is now examining the entire survey, emphasizing the two winter wheat areas excluded from this report where few farmers had taken up new varieties.

The study on which this abridgement is based was undertaken by Dr. Nazmi Demir while a visiting scientist at CIMMYT.

Don Winkelmann

El Batán

I. SETTING THE SCENE IN TURKEY

Turkey's marked dependence on wheat is evidenced in that crop's role in national consumption and in production. On the consumption side, the country's 38 million people have an average annual consumption of some 200 kilos per person a year, among the highest in the world. Wheat supplies roughly 50 percent of the calories and a bit over 50 percent of the protein in the diet of the average Turkish consumer.

On the production side, 8.6 million hectares of land were devoted to wheat in 1972. When the land in fallow—another 8.6 million hectares—is added to this, the wheat industry accounts for some 70 percent of the country's tillable land. Wheat's vital contribution to Turkish agriculture is evident. Given that agriculture employs roughly two thirds of the population, accounts for about a third of GNP, and supplies nearly nine tenths of the country's exports, wheat's overall importance to the Turkish economy is also evident.

With this notable reliance on wheat, the Turkish government has long sought to stimulate production. Its first goal, only occasionally achieved and then only in good years, is to make the country self sufficient in the basic product. Area, yields, and year-to-year fluctuations combine with consumption to make Turkey an importer in all but the best years. These imports range up to 8 percent of annual use.

When considered in the context of a growing population and increasing incomes, the attainment of self sufficiency is seen to be difficult. Population is growing at the rate of 2.6 percent per year. Annual per capita income is increasing at a rate of over 2.5 percent per year. Even assuming a relatively small relationship between changes in income and changes in consumption it is clear that production must increase at a more than 3 percent per year. Closing the gap now filled with imports implies an even greater annual increase in annual production. Contrast this target, however, with the experience of the 15 years, 1958 to 1972, when area increased little and yields increased by a bit less than 2 percent per year.

Sources of Production

The bulk of Turkey's wheat production is now carried on in two quite distinct environments. The largest contributor, both in terms of area and in terms of production, is the winter wheat region of the Southeast, the Anatolian Plateau, and Thrace. These regions account for about 60 percent of the total production on somewhat more than 60 percent of the wheat area exclusive of fallow. Nearly three fourths of the fallow lies in the South East and the Anatolian Plateau.

There is little opportunity to expand production through expansion in area. In fact it is the hope of the government that area in the Anatolian Plateau can be reduced by 500,000 hectares, with all of this returned to pasture.

Yields of winter wheat in Turkey are generally low, on the order of 1.0 to 1.2 tons per hectare. Yields are also characterized by substantial year-to-year variations because of the substantial variation in weather. There is little opportunity for irrigation.

One knowledgeable official emphasizes the need for new varieties adapted to the wheat-fallow rotation, varieties which feature efficient use of available moisture. In addition these vareities must be responsive to such inputs as fertilizer. New varieties now available tend to respond well to inputs but lack yield stability, e.g. Bezostaya under adverse conditions. The land-race varieties, on the other hand, are quite stable but are also quite unresponsive to intensive management practices.

Until recently winter wheats were widely grown under traditional practices. Over the last decade technological change, in the form of tractors, combines, herbicides and fertilizer, has entered the production scene. New varieties have been developed but are not yet widely diffused except in Thrace, an area which will be considered in detail later. Tillage practices for managing fallow and wheat are being developed and promising results are being promoted in a new production project covering 20 provinces in the winter wheat region. It is still too early to see the impact of these efforts to stimulate production. Even so, it is clear that production increases in the winter wheat area will encounter significant hurdles.

All of this implies that no easy solutions are at hand for stimulating rapid increases in wheat production in the major part of the winter wheat producing regions.

Looking now at the spring wheat areas, these are found along Turkey's Aegean and Mediterranean coasts. This zone is characterized by mild winter temperatures and good rainfall, ranging from 500 to 800 milimeters per year.

Some 15 to 20 percent of the country's wheat area and on the order of 25 to 30 percent of the production are found in these coastal regions.

With their emphasis on spring bread wheat, the coastal regions were the natural recipients of new varieties developed in Mexico and Italy. At about the same time the farmers of Thrace, with access to higher and more stable rainfall than the farmers of Anatolia or the Southeast, took up the improved Russian variety Bezostaya.

In the late 1960's these areas, grouped into four regions for purposes of the Ministry of Agriculture—Thrace, South Marmara, Aegean, and Mediterranean regions—became the focal point for government efforts to stimulate wheat production. Starting in 1967 in the spring wheat regions of South Marmara, Aegean and Mediterranean, efforts were intense as the government concentrated on the introduction of new varieties, fertilizers, herbicides, seed treatment, increased seed production; and launched an extension program aimed at growers. The intent of the government was to attain sharp increases in production through yield increases achieved by changing varieties and practices.

Coastal Spring Wheat Programs

The program in the spring wheat area was initiated in 1966 with the importation of some 60 tons of seed of the Mexican variety Sonora. This seed was divided among 100 farmers and grown by them with the counsel of the Ministry of Agriculture. Yields of 4 tons per hectare were obtained, a marked increase over the 1.5 tons from the local tall varieties. Encouraged by these results Government decided to import large quantities of seeds from Mexico, the U.S. and Russia. In 1967, 22,000 tons of HYV seeds were imported and distributed. Most of this was in the Mexican varieties Penjamo, Lerma Rojo, and Super X with some 500 tons of Burt and Brevor from the U.S. and of Bezostaya from Russia.

About 60,000 farmers with 170,000 hectares of land took part in the 1967 program. Pénjamo showed itself quite well adapted to the Turkish scene and became the dominant variety among the imports. By 1969, it was estimated that over 600,000 hectares were sown to the new improved wheats.

The Ministry of Agriculture relied heavily on its extension staff for disseminating information of the new wheat technology. Extension services are essentially in the hands of General Directorate of Agriculture, with headquarters in Ankara. The General Directorate has technical agriculture directors located in each of the country's 67 provinces together with experts and supporting staff in various branches of agriculture.

When the campaign was launched in 1967, few farmers or extension agents were familiar with the new varieties or the complementary agronomic practices. At the outset, Government assigned 250 extension workers to work full time for the new program. These agents were informed through short seminars, informal meetings, and printed materials of the essential points regarding the new varieties and were instructed to promote the complete package to area farmers. The package included preparation of an appropriate seed bed, seeding technique and timeliness of seeding, seed treatment, adequate fertilizer applications, and weed control. All avenues for diffusing information bulletins were produced and distributed, many of them are still in print. These indicate expected yield levels between 4 and 6 tons per hectare under recommended practices and with average weather conditions.

During the first years, with little information yet available from research in Turkey, it was necessary to estimate planting dates and fertilizer recommendations on the basis of experience from other similar environments. These experiences were buttressed by data from an extensive FAO program. This program was started in 1961 and ultimately was responsible for thousands of demonstration plots throughout the country. In time, as Turkish research institutions had the opportunity to focus on the problems of HYV production, a full set of locally-produced recommendations became available.

The Turkish recommendations featured variety and fertilizer but included: preparation of a good seed bed; use of drills for seeding and fertilizer application; application of phosphatic fertilizer at seeding time and of nitrogen in three applications; a seeding density of 80 kilos per hectare; seeding during the period mid-November to late December; weed control when needed; irrigation when needed if available. Seed treatment was also a part of the recommended package as smut (*Ustilago tritici*), bunt and rots can be a problem for Turkish farmers. It was soon discovered, however, that Pénjamo is highly resistant to smut, reducing the need for seed treatment to protection against bunts and rots.

For Turkish farmers market risks and uncertainties are minimized by a price support program of wheat. This program is managed by TMO (Toprak Mahsulleri Ofisi) under the direction of the Council of Ministers. Each year, before the harvest, the Council of Ministers announces prices for each type of wheat (and for some other cereals as well). Farmers can supply an unlimited amount of wheat to TMO at the announced price. The agency has storage space for about 20 percent of the normal crop and maintains more than 300 procurement stations scattered throughout the wheat producing regions. TMO is also responsible to provide the infrastructure and the funds necessary to absorb large increases in production, the sort of thing that might occur from a marked change in technology or from particularly favorable weather. This hasn't been necessary in the recent past, however, as local demand continues to outrun production. It should also be noted that an active private market parallels TMO as local traders, wholesalers, millers,

and speculators compete for annual production.

Farmers also had access to seeds through Government-managed seed production farms. Certified seed is produced on large state-owned farms or under contract by private growers. The seed is then shipped to supply points for purchase by farmers. Seed is priced at 125 percent of the TMO guaranteed price of wheat. It can be bought on credit but only 75 percent of thesvalue of the seed can be loaned to the farmer. This credit system has suffered from serious difficulties in the recent past. Witness the year 1969 when loans by the agricultural banks for commercial seed retailing were 340 million Turkish lira of which 62 million was in default, 100 million was overdue and only 178 million were current. One consequence of this was that credit for seed was notably reduced in the early 1970's and this was accompanied by a dramatic decline in the sale of seed, from a high of over 250,000 tons to a low of under 50,000 tons in 1972.

From 1967 on, the Turkish farmers in the coastal areas had access to HYV's, to some credit, to an active extension program, to a package of recommendations, and to an active, guaranteed market for their product. By 1969 HYV's were estimated to be on over 600,000 hectares for spring wheats and by 1972 the estimated area was over 900,000 hectares.

Review of Subsequent Chapters

This is a dramatic shift to new varieties, from virtually nothing in 1966 to over 50 percent of the spring bread wheat area 7 years later. Still, it was clear that some areas remained with the old varieties or with the old practices. The intent of this study, launched in early 1973 and based on data from the 1971-72 crop year, was to see to what extent a pattern of adoption emerged.

The goals of the study, a description of the study regions, the sample, and the data are discussed in Chapter II. Chapter III presents survey data pertaining to the average profitability of new varieties and fertilizers, and the risks associated with these new inputs. The following two chapters discuss the relationships between adoption of varieties and fertilizer in one hand and farm characteristics, farmer characteristics, and government programs on the other. Conclusion and descriptions of new research are the topics of the final chapter.

II. FARM AND FARMER CHARACTERISTICS IN THE REGIONS STUDIED

The study of adoption of the elements of new wheat technology by Turkish farmers focuses on three spring wheat regions and one winter wheat producing region. The country's remaining winter wheat producing regions are not considered because it was known that few farmers had adopted new varieties by 1972.

Before considering the regions it is convenient to introduce some terms describing wheat varieties. In what follows HYV's are short-stemmed varieties introduced to Turkey from Mexico, from Italy, and from Russia. The major Mexican variety was Penjamo. Italian varieties were Conte-Marzotta, Mara, and Libellula, and the principal Russian variety was Bezostaya. "Other" varieties includes all other varieties, consisting primarily of improved and local Turkish wheats.

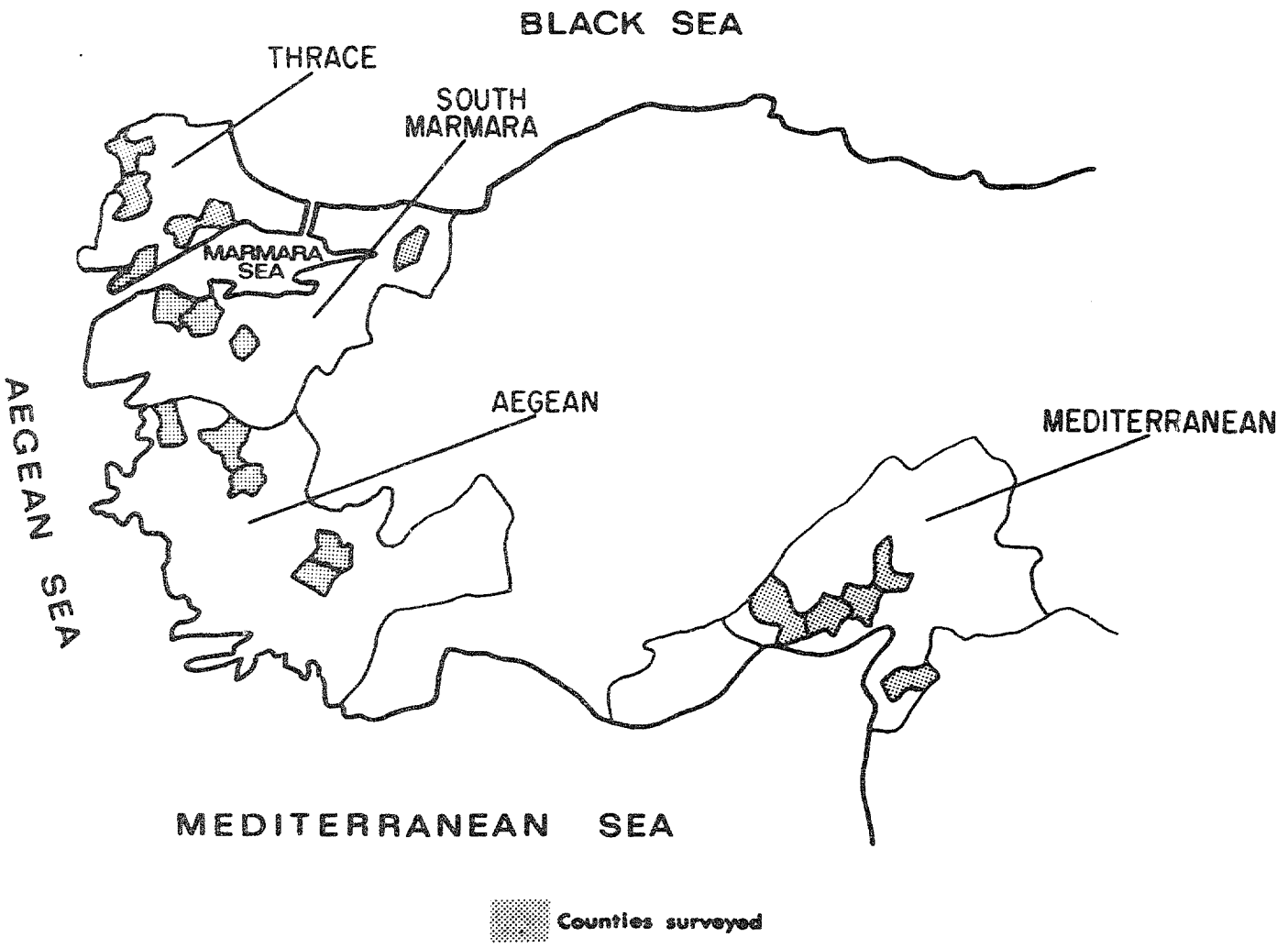
The Regions Studied

For identification, the three spring wheat regions are called Mediterranean (Region 1), Aegean (Region 2), and South Marmara (Region 3) while the winter wheat region is Thrace (Region 4). The regions and the provinces sampled within each are shown in the Map. These regions and representative provinces were identified with the assistance of agricultural scientists familiar with Turkish wheat production practices. Regions were defined so that within each region conditions for wheat production would be essentially homogeneous, except that hillsides and flat lands within a region were assumed to have different characteristics. The analysis, then, recognizes two zones within each of the three spring wheat areas. Only one zone is recognized within the

winter wheat region, as Thrace is characterized by rolling land.

Looking now at the regions, the Mediterranean Region has an annual average precipitation of 934 mm with the monthly distribution over the 5 years, 1967 to 1971, as shown in Figure 1. The average elevation is 20 meters. Wheat is planted in November and harvested in May. Wheat makes up some 30 to 60 percent of the average farmers' crop mixture. Because HYV's can be harvested in May a second crop often follows wheat. While the area has a well developed irrigation system, wheat is rarely irrigated as rainfall is usually quite adequate. Spring frosts rarely occur and there is little damage attributable to hail or to wind. The region accounts for roughly 10 percent of Turkey's wheat area and some 13 percent of the total production. The provinces chosen for sampling are less representative of the entire region than is the case for the other three regions studied. While this restricts generalization of the data to the eastern part of the region, that part does account for the bulk of the region's area and production.

The Aegean Region has an annual average precipitation of 670 mm. The monthly distribution for the 5 years, 1967 to 1972, is as shown in Figure 1. The wheat season extends normally from the beginning of December to the middle of June. Somewhat less than 50 percent of the wheat is produced in the Region's main valleys and the rest on the adjacent sloping lands and foothills, at elevations ranging from 20 to 500 meters. The higher elevations are subject to spring frosts. While the local wheats, which mature late, are rarely influenced, frost can damage the earlier maturing spring HYV's. In the valleys wheat is usually grown in rotations with cotton and pulses while on the hillsides tobacco and wheat are featured. Wheat is harvested in late May and early June. As in the Medi-



The Thrace, South Marmara, Aegean, and Mediterranean regions of Turkey and the surveyed counties within each region.

terranean Region, irrigation is available but little is practiced on wheat. The region accounts for some 7 percent of the wheat area and 9 percent of total production.

South Marmara Region averages 680 milimeters of rainfall annually and elevations of cultivated lands range up to 250 meters. Average monthly distribution of rainfall for the period 1967 to 1971 is given in Figure 1. Major field crops in addition to wheat are sugar-beets, tobacco, pulses, sunflower, and potatoes. Wheat is harvested in July, 20 to 30 days later than in the Aegean Region. South Marmara has 4.5 percent of Turkey's wheat area and 3 percent its production.

Unlike the coastal regions, Thrace is a winter wheat area. Annual average precipitation is 590 millimeters, distributed as shown in Figure 1 (data from 1967 to 1971). Wheat is the dominant crop with sunflower following in importance. Thrace has nearly 6 percent of the country's wheat area and contributes a bit over 7 percent to total production.

Sampling Strategy

After identifying essentially representative privinces from each region, counties were selected at random from each province. Within each county villages were stratified in

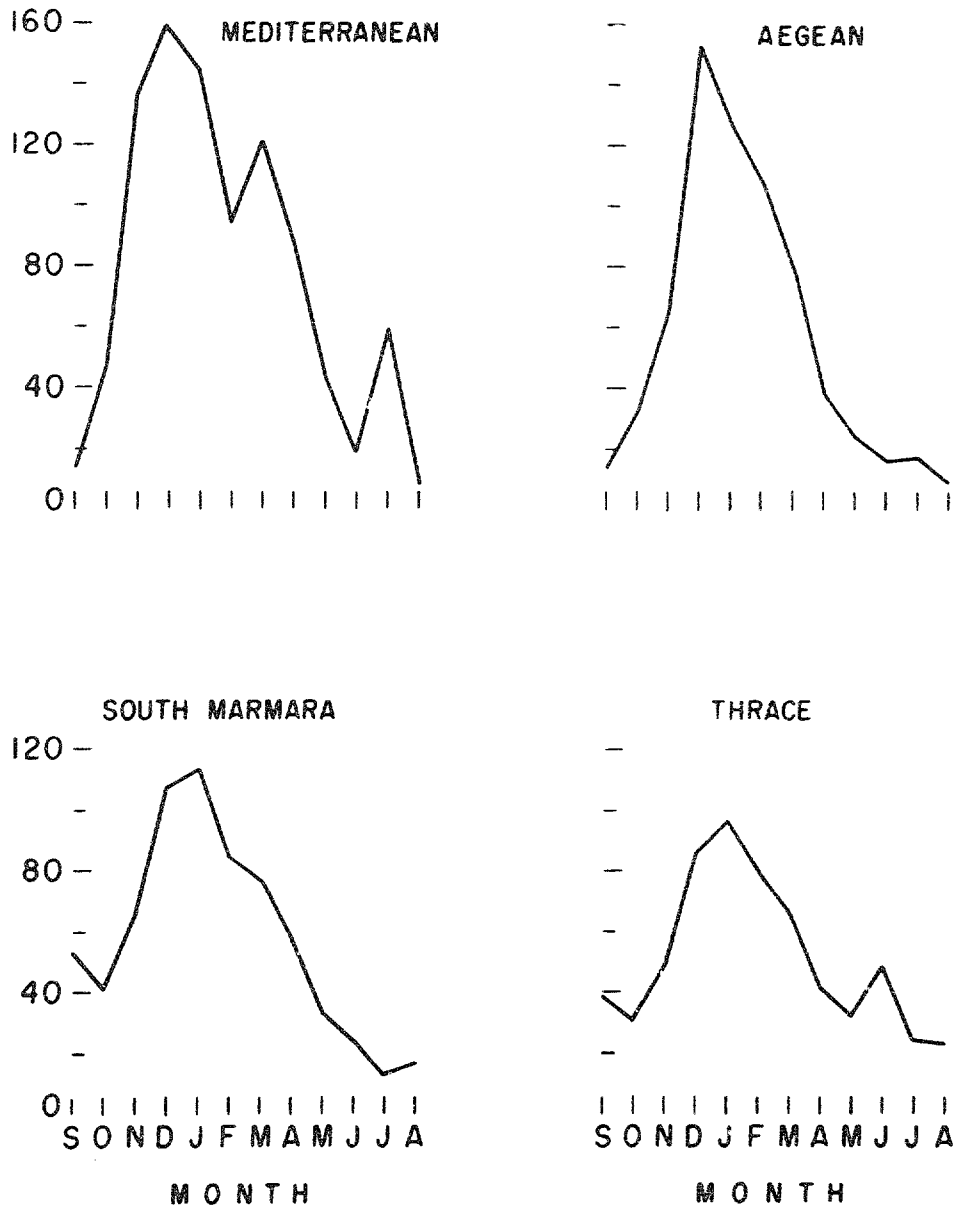


Fig. 1. Average monthly millimeters of precipitation by region (1967-71).

Table 1. **Characteristics of sampled wheat farmers by region.**

	Mediterranean	Aegean	S. Marmara	Thrace
Age	52	49	47	56
Family size	7.8	6.2	5.5	6.0
Education [a]	2.4	2.3	2.1	2.3
Days working off-farm/year	13.5	13.5	9.9	12.5
Plowing with tractors, %	94	45	38	82
No. agr. radio programs/month	6	3	5	7
Participating field days, etc. [b] %	51	10	39	38
Membership in agric. society, [c] %	81	55	79	96
Selling wheat, %	82	33	25	79

a/ Range: 1-7 (1 = no education 7 = college education. *b/* Field days, lectures, and demonstrations. *c/* Membership in any of several agricultural societies ranging from co-ops, 4-H clubs, etc.

Table 2. **Characteristics of farms of sampled bread wheat farmers.**

Region	Size (ha)	Bread wheat Land in (%)	Bread wheat Plots (no.)	Bread wheat Plots on hillside (%)	Distance from home to fields (km)
Mediterranean	14.6	67	1.9	67	2.6
Aegean	5.8	46	1.6	75	2.3
South Marmara	7.0	48	–	77	1.8
Thrace	15.2	48	–	96	2.3

a/ Virtually all durum farmers eliminated and those durum plots included are not considered as part of bread wheats.

Table 3. **Percent of fields and percent of area devoted to various varieties on sampled bread wheat farms, by region.**

	Mediterranean		Aegean		S. Marmara		Thrace	
	Fields	Area	Fields	Area	Fields	Area	Fields	Area
Bezostaya	–	–	5.7	2.4	7.1	20.7	76.0	78.7
Italian [a]	1.8	1.5	–	–	11.4	10.3	–	–
Mexican [b]	93.1	95.4	23.0	32.7	7.9	8.6	–	–
HYV's	94.9	96.9	28.7	35.1	26.4	39.6	76.0	78.7
Other [c]	5.1	[illegible].1	71.3	64.9	73.6	60.4	24.0	27.3

a/ Conte x Marzotta, Mara, and Libellula. *b/* Penjamo, Lerma Rojo 64, Super X, Sonora 64 with Penjamo by far the most prominent variety. *c/* Other includes land race varieties and pre-dwarfs improved varieties, largely Turkish. Local improved accout for about one-fourth of other in Aegean and nearly one-third of other in South Marmara.

terms of topography, weighted in terms of wheat area, and two sets of villages were selected at random. Roughly 30 villages from each region were selected in this manner. Within selected villages, farmer households were stratified into three groups according to farm size and then farmer households were selected at random. Roughly 200 households were interviewed from each region. Some of those farmers interviewed were subsequently eliminated because they concentrate on durum wheats. If durum occupied over half of the farmers' wheat area he was eliminated from the sample. No HYV durums were available to Turkish farmers in 1971. This left a sample size of 200 farmers in Mediterranean Region, 154 in Aegean, 177 in South Marmara, and 178 in Thrace. In most cases, farmers who reported some durums had all of their wheat land in durums.

Dr. Resat Aktan figures prominently in all of the early stages of this study, from planning its scope, to formulating hypotheses, to preparation of the questionnaire, and to administering the survey. Survey administration was completely in Dr. Aktan's hands. Ennumerators were provided by the Ministry of Agriculture, largely from its extension staff. Turkey's State Institute of Statistics also provided counsel on statistical techniques and accomplished the task of transfering the data to punch cards. It should also be mentioned that, while none of the data are reported here, some 500 farmers of Anatolia Region and Southeastern Region were interviewed. Those data are now under analysis, with the aim of establishing the characteristics of current practices.

Several statistical techniques were used in analyzing the data. These included simple chi-square tests, analysis of variance, multiple regression, and logit analysis. While a number of variables were considered (see Foreword for a description of hypotheses) major attention was focused on agro-climatic region and farm size.

Regional Characteristics from Survey Data

Data from the survey can be used to augment the cursory description in the first section of this chapter. Certain characteristics of farms and farmers are given in Table 1 and Table 2 while data on the use of the HYV's by regions are in Table 3.

Some comparisons among regions are interesting. Notice that average age in Aegean and South Marmara is well below that in Thrace. Family size in Mediterranean is far larger than in other regions. Little off-farm work is undertaken. Tractor use is far more frequent in Mediterranean and Thrace than in Aegean or South Marmara. Notice that Aegean is well below the other regions on extension-related variables (radio programs, field days) and on membership in agricultural societies. Thrace ranks quite high on agricultural societies. Finally, both Aegean and South Marmara fall well below Mediterranean and Thrace in percentage of farmers selling wheat.

Table 4. **Distribution of sampled farmers by average quantities of plant nutrients (nitrogen and phosphorus) applied to bread wheat in 1971 72 production.**[a]

(kg/ha)	Mediterranean (%)	Aegean (%)	S. Marmara (%)	Thrace (%)
0-30	6	54	38	6
31-60	7	26	20	14
61-90	12	14	23	29
91-120	17	4	16	21
121-150	20	2	3	14
151-180	19	–	–	11
over 180	19	1	1	5
Total	100	100	100	100
Mean (kg/ha)	131	34	50	99

a/ Recommended levels are: for HYV's, 160-200 kg/ha; for others, 120-140 kg/ha.

Average farm size for sampled farmers is a good bit smaller in Aegean and South Marmara while percentage in wheat is far larger in Mediterranean. South Marmara farmers live closer to their plots on the average. Mediterranean farmers have the lowest percentage of their land on hillsides and rolling land.

Clearly Aegean and South Marmara lagged behind Mediterranean and Thrace in use of HYV's. Notice too that in Mediterranean and Thrace there is little evidence that size is related to adoption while in Aegean and South Marmara there is some evidence of such a relationship as percentage of area is larger than percentage of fields.

Two additional points should be made. If one compares the regions in terms of "adoption" of HYV's where adoption is defined as having more than 50 percent of the spring or winter wheat lands in HYV's, then the rates are 93 percent for Mediterranean, 29 percent for Aegean, 31 percent for South Marmara, and 72 percent in Thrace. The second point relates to durum wheats. While virtually no durum wheat was produced by the sampled farmers of Mediterranean, 30 percent of the plots of the Aegean farmers interviewed were in durums, 15 percent of those in South Marmara, and 8 percent of those in Thrace.

Similarly, the farmers of the four regions can be grouped according to fertilizer use. The result is seen in Table 4.

As with HYV's, fertilizer is most heavily used in Mediterranean and Thrace, falling sharply in Aegean and South Marmara. It should be noted that fertilizer use on wheat has increased appreciably since the introduction of the HYV's. In 1966-67 it was estimated that wheat absorbed

28 percent of the total plant nutrients used in agriculture. By 1972, wheat was estimated to take up 60 percent of all nutrients used in agriculture. Based on the survey results the four regions under study used nearly 30 percent of the nutrients applied to all wheat. Even so, there is apparently some way to go before applications reach recommended levels, which are 130-200 kg/ha for HYV's and 120-140 kg/ha for other varieties.

III. FARMER INCENTIVES FOR ADOPTION OF RECOMMENDATIONS

This chapter treats results of analyzing the data from the bread wheat farmers interviewed in conjunction with the 1971-72 production survey. Anticipating the conclusions it will be seen that differences among regions exercise the most notable influence on the pattern of adoption of HYV's and on fertilizer use.

Before examining the data from the survey it is appropriate to review the elements of the new technology. These were: 1) HYV's, 2) increased use of fertilizer, 3) better seed bed preparation, presumably with tractor-drawn implements, 4) seed treatment, 5) proper seeding dates and rates, 6) seed and fertilizer applications with drills, 7) and weed control. These will be covered in turn below with emphasis given to use of HYV's and fertilizers.

Measures of Profitability of Recommended Procedures

There is a presumption that by following recommended procedures farmers will realize greater per-hectare profits than from following more traditional practices. This presumption is solidly backed by experimental data from each of the regions. There is still the question of how farmers fare when they incorporate these practices.

An earlier study undertaken by the Ministry of Agriculture[1] in 1968 showed that a sample of 55 farmers had average net returns of 1810 Turkish Lira for HYV's while a sample of 44 farmers had net returns of 791 TL per hectare from local varieties. This study also showed a considerable difference in use of fertilizer and implements between the two sets of farmers.

To get an impression of relative yields under more nearly similar conditions sample farmers were asked about their yields for the 1971-72 crop year. It was not worthwhile to group their responses in terms of all of the elements of the new technology as, with some 128 simplified combinations per region, the substantial variation among farmers permits only a few observations for each combinations of elements. It is, however, meaningful to group responses in terms of variety planted and fertilizer use. The results are shown in Table 5. Even so, it must be remembered that data are farmers' recollections of yields, hence are subject to a certain margin of error. This presentation has the significant advantage of having maintained fertilizer use relatively constant between the two classes of seed. Even so, as many other important elements are left uncontrolled in Table 5—e.g. preceeding crop and seeding date—the yields are little more than indicative of the relative profitability of the practices which are being considered. Notice for example, that larger applications of fertilizer seem to be warranted in only three of the nine comparable cases—South Marmara hillsides for both HYV's and other varieties and Thrace for other varieties. In the remaining six cases, the yield differences are short of the roughly 200 kilos of extra wheat needed to buy the extra fertilizer, e.g. for Aegean flat lands under HYV's, the reported difference in yields associated with higher fertilizer use is only 90 kilos. This is a measure of the influence of the uncontrolled elements and, perhaps, of errors in reporting yields.

In any case, before relative profitability can be assessed some additional adjustments must be made. First while relatively few of the sampled farmers reported selling straw (7 percent, 4 percent, 12 percent and 29 percent respectively in the four regions), they do report that a market exists and many use the straw for maintaining their own animals. Assume that the relative proportion of usable dry matter is partitioned 40 percent to grain and 60 percent to straw in HYV's and 32 percent and 68 per-

cent in local varieties and that the price of straw is 30 percent of the price of grain (sampled farmers reported prices varying from 25 to 35 percent). Then the added grain needed to offset the implied straw foregone from the data in Table 5 is seen in Table 6.

A second adjustment can be made because, according to Turkish government estimates, even when adjusting for fertilizer, HYV's cost roughly 100 kilos of wheat per hectare more to produce than do local varieties. These are said to be the additional costs of harvesting and tending the HYV's. This estimate seems high for several of the regions where reported yield differences between HYV's and Other varieties are low e.g. Thrace hillsides.

Adding these costs together, deducting them from the reported yields of HYV's and then deducting the reported yields of ordinary varieties leaves the net extra yields shown in Table 7.

These calculations—based on farmers' reports of yields, an assumption about grain partition, the assumption that average fertilizer use within the respective fertilizer groups is the same for HYV and other groups—indicate that HYV's, produce relatively more profits than other varieties in all but two situations. Those two are South Marmara hillsides for low fertilizer users and Thrace hillsides for high fertilizer users. Again, we mus emphasize the operative verb "indicate" as these two results are certainly counter to expectations.

One interesting aspect of Table 5 and Table 7 is that in four of six hillside situations, the HYV's appear to be more profitable than the other varieties. This runs counter to the conventional wisdom of the countryside which has held that HYV's are not useful on hillsides. The latter view has received some support from the Extension Service which has not given the same emphasis to HYV's for Aegean and South Marmara hillsides that it has given to HYV's for valley farmers.

It can be asked why the yields of Table 5 are so much below the 4 to 6 tons yields cited by Experiment Stations and regularly achieved on some farms. In significant measure, this occurs because farmers have not taken up all the practices recommended by agricultural scientists. Table 8 is a graphic demonstration of this assertion.

For the Aegean Region perhaps the most notable issues

Table 5. **Average yields (kg/ha) of bread wheats reported by sampled farmers for 1971-72 by variety, fertilizer use, and agro-climatic zone.**

Region	Zone	HYV Low fert. [a]	HYV High fert. [a]	Other Low fert. [a]	Other High fert. [a]
1. Mediterranean	Flat lands	*b*	2518	*b*	1750 [c]
	Hillsides	1556	*b*	950 [c]	*b*
2. Aegean	Flat lands	2204	2294	1727	*b*
	Hillsides	1448	1533	1057	1134
3. S. Marmara	Flat lands	2430	2375	1477	1550
	Hillsides	1063	1833	1008	1332
4. Thrace	Hillsides	1947	1811	1278	1600

a/ Low fertilizer is 0-60 kg/ha of nutrients in Regions 1, 3, and 4, 0-50 kg/ha in region 2. High fertilizer is 110-150 kgs. in region 1, 60-100 kg/ha in region 2, 80-100 kg/ha in regions 3 and 4. *b/* No data reported. *c/* Fewer than 10 observations.

Table 6. **Grain equivalent of extra straw produced by HYV's as implied by yields of Table 5.**

Region	Zone	fertility Low	fertility High
Mediterranean		–	–
Aegean	Flat lands	-91	
	Hillsides	-18	-27
South Marmara	Flat lands	127	67
	Hillsides	-137	20
Thrace	Hillsides	51	170

Table 7. **Net yield advantage (kg/ha) of HYV's over other varieties after accounting for value of straw and certain other costs.**

Region	Zone	fertility Low	fertility High
Mediterranean		–	–
Aegean	Flat lands	286	
	Hillsides	273	272
South Marmara	Flat lands	980	792
	Hillsides	-182	381
Thrace	Hillsides	620	-59

Table 8. **Farmer practices by type of wheat and region in 1971-72 production.**

	Mediterranean		Aegean		S. Marmara		Thrace	
	HYV	Other	HYV	Other	HYV	Other	HYV	Other
Fertilizer (kg/ha	133	–	62	22	70	42	109	73
Treated seeds (% of fields)	61	21	77	68	98	75	97	84
Drilled wheat (% of fields)	2	0	5	1	4	15	6	2
Recommended date (% of fields)	94	–	41	–	63		–	–
Weed control (% of fields)	20	10	25	12	87	52	33	32
Drilled fertilizer (% of farms)	2	0	0	0	0	0	–	–
Split applications fert. (% of farms)	78	48	92	70	81	59	67	5

are the low rates of fertilizer application and the low percentage of farmers planting HYV's at the recommended time. Weather was also a problem according to reports from the Aegean Regional Agricultural Research Institute as some 200 millimeters less than the normal rainfall was received.

South Marmara is also distinguished by low rates of fertilizer applications as compared with recommendations and by a significant portion of farmers who do not seed at the recommended time.

Thrace shows up quite well except for split applications of fertilizer. This may well be a less critical problem for the winter wheats and the rainfall regime of Thrace than in the spring wheat regions.

While irrigation is potentially available to many of the farmers cultivating spring wheats, few take advantage of it. According to the survey, Aegean Region farmers irrigate less than 10 percent of their spring wheat area, and most of this is applied to improved varieties. The remaining regions report less than 1 percent of their spring wheat under irrigation and Thrace reports roughly 1 percent of its winter wheat under irrigation.

One final point must be made before proceeding to the question of risk. In the summer of 1975, Mexican varieties were selling at a discount as compared with local varieties in the market towns of the Aegean Region. The discount was on the order of 10 percent and is attributable to the red grain of the Mexican varieties. This gives a reddish tint to locally ground flour while the local amber colored varieties produce a whiter flour through local mills. Given the local preference for white flour the local varieties are sold in the market towns while the Mexican varieties are shipped to major mills.

On the other hand, no price differential was indicated by the survey. An explanation of this apparent contradiction is that the harvest of 1972 sold at the government support price with sufficient grain available that TMO could maintain the price. By 1975, however, domestic and world shortages along with Turkey's inflation pushed market prices above support prices as local preferences were manifested. At the time of the survey in any case, as price differentials were small or nonexistent, they had little effect on adoption of improved varieties.

With respect to profits, then, experimental data, Ministry survey data, and the 1971-72 production survey data combine to support the argument that HYV's are more profitable than other varieties, even when both are managed in roughly the same way. Notice, too, that the net yield differences reported in Table 7 represent proportionately larger increases in net profits per hectare than in net yields per hectare. For example, using simple averages, the net yield increase of Table 7 over the other varieties of Table 5 is over 25 percent. Since other costs must be netted from the base yields, the relative increase in profits is of a substantially larger magnitude.

Measures of Risks of Recommended Procedures

Looking now at risk, the situation is less clear than for profits. It appears that the growing conditions in the Mediterranean Region for HYV spring wheats and in Thrace for HYV winter wheats are such that there is no more risk associated with their introduction than with other varieties. Mediterranean farmers face little danger from frost and have not experienced major disease problems. Thrace is blessed with good moisture hence the criticism applied to Bezostaya that yields are unstable because of moisture stress is not applicable. Farmers of these two regions respond with high adoption rates and also are using heavy fertilizer applications.

Circumstances are quite different, however, in the Aegean and South Marmara areas where late frosts, especially in the hills, can be devastating. One of the most critical factors affecting yields of the Mexican varieties is time of seeding. Bill Wright, working with Turkey's Wheat Research and Training Center, states that "Perhaps the worst thing you can do to a short duration type wheat (in Turkey) is to sow too early." Seeded early and with high temperatures during early growth, tillering is restricted and the plant moves quickly into the reproductive phase. If frost occurring while the plant is flowering, yields can be severely reduced. Sown later, this phase occurs after all but the latest frosts.

On the other hand, late seeding can also be undesirable. Demirticamak of the Wheat Research and Training Center points out that, if seeding is late, rains can delay planting even more, leading to poor emergence and inadequate stands if wet conditions persist.

These constraints, especially that arising from frost, put the Mexican varieties at a relative disadvantage in South Marmara and Aegean as compared with Italian or other varieties. These varieties are of longer duration, hence, even if seeded early, have a high probability of escaping damage from frost. This is probably one of the factors explaining the relatively low adoption of Mexican varieties and the correspondingly higher adoption of Italian varieties in South Marmara. As Table 3 shows, South Marmara has more area in Italian than in Mexican varieties. It has more area in improved winter wheats than in the total of Italian and Mexican spring wheats. The heavier use of winter wheats is a measure of the relatively cooler temperatures prevailing in South Marmara, especially in the hills where nearly 90 percent of the Bezostaya is grown.

This last point, it should be noted, is an adverse commentary on the homogeneity of the hillside areas of South Marmara. If some of the hills of that region support winter wheats (Bezostaya) while others support spring wheats (Italian, Mexican, and other), then these two sets of hills are clearly not part of a homogeneous agro-climatic zone.

Disease is also playing a role in farmers' assessments of the desirability of adopting new varieties. Some early users

of these varieties, especially in Aegean and South Marmara, suffered when their HYV's showed far more susceptiblity to Septoria than did local wheats in the attack of 1970. Penjamo withstood the attack reasonably well. Still, in the minds of some farmers, the new varieties are suspect because some of them manifested great susceptibility to this now-and-again scourge of wheat growers in the Mediterranean littoral.

Other diseases, the most important being yellow rust, are special problems in Aegean and South Marmara. Here, however, it appears that the Italian varieties and Penjamo show better resistance than do the local varieties.

Looking now at precipitation, the monthly rainfall patterns seems to be less favorable to HYV's in Aegean and South Marmara Regions than in the Mediterranean Region.

Discussions with scientists[2] indicate two different stages in wheat's growth cycle. At these stages minimum amounts of moisture are critical. The first critical stage is at crown root initiation, which starts 3 to 4 weeks after seeding. The second critical stage is at flowering and early in the seed filling period. This usually occurs some 130-150 days after seeding, depending upon the environmental conditions. The threshold moisture level below which yields are lower than expectations needed for these two critical stages vary depending upon several factors. Given the conditions existing in the coastal regions of Turkey, a rule of thumb that seems reasonable is that 40-50 mm rainfall either in December or January or both, (roughly when crown roots develop) and 60-70 mm of rainfall in either March or April or both (flowering and early filling stage) is usually sufficient for a good harvest. Assuming the lower figures as the threshold levels, Table 9 shows the probabilities of having amounts of precipitation more than or equal to the thresholds. The probabilities are based on monthly observations of the past 15 years averaged over several localities.

As is observed from Table 9, rainfall is not likely to be a limiting factor in the coastal regions at the crown root development stage. The probabilities of having rainfall equal or above 40 mm are very high. However, rainfall seems to be an important factor at the flowering and early filling stages. Probabilities of having rainfall equal to or above 60 mm in March and April are highest in the Mediterranean Region with 63 percent and considerably lower in Aegean and South Marmara. This is consistent with the higher adoption rate of HYV's in Mediterranean and lower adoption rates in Aegean and South Marmara.

Perhaps even more significant is rainfall's influence on rates of fertilization. With the higher probability of late rains in the Mediterranean Region, farmers can be more confident of adequate moisture, hence would tend to be more disposed to accept the costs of high rates of fertilizer. This is certainly consistent with the behavior of Mediterranean farmers (see Table 4). The probabilities do not properly order the Aegean and South Marmara regions with respect to fertilizer use but this might be influenced by the higher temperatures and evaporation rates of the Aegean. These conditions can impose an even greater need for moisture in that region than in South Marmara. With this, the threshold level in South Marmara might be overstated relative to Aegean. If so, the probability of achieving threshold levels is understated.

Frost and disease are also playing a role in fertilizer use. If farmers must be concerned about disease, frost, and precipitation, whether on local or improved varieties, they tend to use fewer complementary inputs in production. These considerations might well explain the markedly lower fertilizer use found in Aegean and South Marmara (Table 4), where risks are relatively higher than in Mediterranean.

Summary

While not conclusive, the data presented in this chapter suggest that HYV's are more profitable than local varieties under virtually all of the circumstances covered by this study. From the data in Table 5, fertilizer does not appear to be profitable in Aegean and South Marmara, where average rates of application are low, not in Thrace where average rates of application are high. Neither HYV's nor

Table 9. **Estimated probability that rainfall will exceed specified threshold levels by region.**

Region	Crown root development Pr. (precip. > 40 mm in Dec. and Jan.)	Flowering and early filling Pr. (precip. > 60 mm in March and April)	HYV Adoption rates[a]
Mediterranean	0.94	0.63	94.9
Aegean	0.93	0.43	28.7
South Marmara	0.93	0.37	26.4

a/ Percent of fields under HYVs.

local varieties manifest a profitable response to fertilizers according to the data of Table 5, certainly an anomalous result.

The discussion on risk outlined several ways in which risk might be influencing the adoption of HYV's. It was seen that both regions with low adoption rates—Aegean and South Marmara—experience relatively more climatic risk from disease, frost and rainfall than do the regions with higher rates of adoption.

Notes

1. Denizli Ilinde Pamuk, Mekiska Bugdayi Cesitleri ve Akbasak Bugdayinin Mukayes eli Ekonomik Analizi (1967-68), Tarim Bak. Planlama ve Ekon. Arast. Dairesi Bask. Yayin No. 36, Ankara 1969.

2. Private discussion with Dr. Glenn Anderson and Dr. Sanjaya Rajaram at CIMMYT, Mexico.

IV. ADOPTION AND CHARACTERISTICS OF THE FARM, FARMER, AND GOVERNMENT PROGRAMS

A number of variables expected to be related to farmers' decisions to adopt new technological practices are presented in the Foreword. Included are characteristics of the farm, of the farmer, and of government programs related to the technologies being considered. In this chapter we present the survey data in a number of ways, showing the relationships between adoption of new practices and each of these factors in two-way tables. In the following chapter we present the results of multivariate analysis of the effect of the factors on adoption when considered simultaneously.

HYV's and Individual Variables

The new wheat varieties were introduced to Turkish farmers on a large scale in 1967 after extensive trials in 1966. Most of these HYV's were imported from Mexico along with Bezostaya from Russia. Accompanying the importation of the seed, the Ministry of Agriculture launched a dramatic program to promote use of the varieties and of complementary agronomic practices. By 1972, Penjamo, a variety from Mexico, occupied 70 percent of the coastal area seeded to HYV of bread wheats while Bezostaya accounted for all of the HYV's grown in Thrace (See Table 3).

Farm size and topography. With respect to topography, the term "flat lands" refers to land actually in valleys or on flat plains. In forming the two farm-size categories, each sub-region's farms (e.g. the farms of Aegean hillsides) were arrayed by size and divided evenly into two groups. The range of farm sizes and the proportion of farmers falling into each group is given in Table 10.

Within regions and holding farm size constant, the effects of topography are consistent in that flat lands always have higher HYV adoption rates than hillsides (Table 11). This result accords quite well with the discussion. Differences are small in Mediterranean where overall adoption rates approach 100 percent and are substantial in Aegean where disease and frost conspire against HYV spring wheats while climate is not right for winter wheats. In contrasting smaller farms with larger farms within region by topography classes, the effect of farm size is usually positive. There are two exceptions to this, that in Mediterranean flat lands is small while that in South Marmara flat lands is notable. Only one other difference exceeds 20 percentage points, that between smaller and larger farms in Thrace.

It was hypothesized that flat lands would show larger adoption rates than hillsides and larger farmers would lead smaller farmers. In general this is true but differences in adoption rates related to farm size are small with the single exception of Thrace. It might well be that larger farmers adopted first, followed by smaller farmers, in which case earlier differences would have been larger. By 1972 however, 5 years after introduction of new varieties, large differences are not evident. It is clear that the impact of topography exceeds that of farm size.

Age, education, and membership in agricultural societies. Table 12 relates adoption of HYV's to three characteristics of farmers. No simple relationship between adoption and age is evident. Only in the case of Mediterranean Region is it true that younger farmers lead older farmers in the use of improved varieties.

Education and adoption of HYV's do show a consistent relationship across each of the four regions. In each region the average education of adopters is higher than the average education of those who use other varieties.

Turkish farmers have access to a wide range of agricultural

Table 10. **Range of farm sizes for sampled farmers by sub-regions and proportion of sampled farmers in each sub-region.**

Region	Zone	Size (ha.) Smallest	Size (ha.) Largest	Proportion (%) Smallest	Proportion (%) Largest
Mediterranean	Hillside	0.1-6	6.1 125	33.5	33.5
	Flat lands	0.1-8	8.1-150	16.5	16.5
Aegean	Hillside	0.1-3.8	3.9-37	37.5	37.5
	Flat lands	0.1-4.5	4.6-22	12.5	12.5
S. Marmara	Hillside	0.1-4.3	4.4-108	38.6	38.6
	Flat lands	0.1-3.3	3.4-15	11.4	11.4
Thrace	Hillside	0.1-7.9	8-128	50	50

Table 11. **Adoption of HYV's [a] among sampled farmers by size of farm, [b] region, and topography [b] (percent).**

Region	Zone	All farmers	Smaller farmers	Larger farmers
Mediterranean	Flat lands	96	95	97
	Hillsides	91	92	90
Aegean	Flat lands	69	60	77
	Hillsides	14	4	23
South Marmara	Flat lands	57	70	43
	Hillsides	22	13	32
Thrace	Hillsides	70	62	85

a/ Mexican, Italian, and Russian varieties. *b* See table 10 and discussion.

societies. Among these are Chambers of Agriculture, Agricultural Credit Cooperatives, Agricultural Sales Cooperatives, Village Development Cooperatives, and 4H Clubs, (clubs emphasizing the teaching of agricultural skills of young people). For the sampled farmers, coops were the dominant kind of society with over two thirds of those reporting some kind of association being members of cooperatives. As with education, a consistent pattern emerges across all four regions with adopters of HYV's reporting greater membership in agricultural societies than do users of other varieties. Members of such societies, especially members of cooperatives, are said to have easier access to credit and to such inputs as improved seeds and fertilizers than has the farmer who is not affiliated. It is notable that such a large portion of the sampled farmers in Mediterranean and Thrace regions report membership in such agricultural societies.

It should be noted that age and education are negatively correlated for Turkish farmers. The simple coefficients of correlation are −0.52, −0.45, −0.43 and −0.61 for Mediterranean, Aegean, South Marmara, and Thrace regions respectively.

Risk aversion: Earlier discussion has argued that HYV's are more sensitive to the vagaries of weather and to some diseases than are local varieties. For example, late frosts were described as having more serious consequences for Mexican HYV's than for local varieties. Mexican HYV's are also thought to be more susceptible to Septoria than the Italian HYV's or local varieties. On the other hand, local varieties are more susceptible to rusts than are the HYV's.

The occurrence of late frost, of Septoria, and or rust is unpredictable except in probabilistic terms. Thus, in those regions where late frost or Septoria are thought to be major problems, farmers planting Mexican HYV's tend to be exposing themselves to more risks than those planting local varieties. The converse is true in areas where rusts are prevalent.

Late frosts will tend to be a greater problem in the higher hills and in South Marmara followed by Aegean than on the plains or in the Mediterranean region. Even though the last severe outbreak of Septoria, in 1969, occurred in Mediterranean region, the agro-climatic characteristics of South Marmara tend to be most favorable to Septoria's development. Stripe rust tends to be most notable in South Marmara and stem rust in Aegean. The Mediterranean Region suffers little from either.

On the basis of these natural risks and the foregoing description of the varieties, we would expect Mexican varieties to have a clear advantage in Mediterranean Region and a lesser advantage in South Marmara and the high hills of Aegean because of Septoria and late frost. Italian varieties would tend to have an advantage in South Marmara because of Septoria resistance. On the basis of risk considerations, Mexican HYV's would tend to be preferred over Italian HYV's in Aegean flat-lands, where frost is not a factor but stem rust is, with roughly comparable risks on the higher hills where frost threatens the early maturing Mexican HYV's more than the later Italian HYV's.

Table 12. **Age, education, membership if farm organizations, and adoption of HYV's by region for sampled farmers.**

Region	Seed	Average age (years)	Average education [a]	Members [b] (%)
Mediterranean	HYV	51	2.5	97
	Other	58	1.9	85
Aegean	HYV	50	3.0	40
	Other	47	2.2	10
South Marmara	HYV	48	2.6	30
	Other	47	2.0	15
Thrace	HYV	54	2.5	72
	Other	53	2.4	69

a/ The averages are based on coded values, e.g. "never went to school" is coded 1 while "graduate of college" is coded 7. *b/* The partitioned sets are adopters and non-adopters so that, e.g. for Thrace, of those using HYV's 72% are members of an agricultural society.

With respect to Thrace, the Mexican and Italian HYV's are simply not relevant as winter wheats are required. This leaves the field there open to Bezostaya. Bezostaya is also sometimes found in the higher hills of Aegean and South Marmara where climate calls for a winter wheat. This, of course, is an adverse comment on the homogeneity of the agro-climatic regions as they were drawn.

In an effort to relate risk, farmer's perceptions of risk, and the adoption of HYV's, an index of optimism was constructed for each farmer. The index is the ratio of bad and normal yields divided by the relative probability which the farmer assigns to bad and normal weather.[1]

The range of the index is from zero to infinity with zero occurring when yields in a bad year are held to equal to zero or when the probability assigned to normal weather is zero. As the relative yields in bad years approach 1 or as the subjective probability of the occurrence of a bad year declines the value of the index rises.

Only normal and bad years are considered in the index because of the assumption that income-seeking risk-averting farmers worry most about the consequences of bad weather. This is roughly in line with the treatments of Roy[2], Telser[3], and Kataoka[4] where it is argued that the probability of getting income below some critical level plays an important role in decision making.

To quantify farmers' perception about nature, sample farmers were asked to guess yield levels obtainable in their best fields under bad, normal and good weather conditions. They were also asked to tell how many bad, normal, and good years they expected in the next 10 years. Nearly all of the farmers responded to the question on yield levels. Only some 10 percent responded to the question on the fequency distribution of bad, normal and good years. For those farmers not responding to this question, it was arbitrarily assumed that each outcome has equal probability, i.e. the Principal of Insufficient Reason was invoked. For farmers not responding to the question on weather, then, the optimism index is simply the ratio of yields in years of bad weather to yields in years of good weather.

Farmers responding to the question on the relative frequency of various kinds of weather were grouped according to the class of wheat seed they used. The results are shown in Table 13. For each region save the Mediterranean, adopters of HYV's expected fewer years of bad weather than did users of local varieties. No users of local varieties responded to the question in the Mediterranean. Only in the case of South Marmara is the number of respondents sufficiently large to permit placing much faith in the frequencies reported. It should be pointed out that interesting comparisons are those between HYV and Others within regions. Comparison between regions has little meaning. A more interesting comparison, of course, would have been between adopters and others within topography classes but the limited number of observations makes these comparisons dubious.

Table 13. **Relative frequency of bad weather as related to use of HYV's and local varieties by region.**

	Mediterranean	Aegean	South Marmara	Thrace
HYV's	0.24	0.20	0.12	0.23
Others	*a*	0.31	0.32	0.37

a/ No observations.

Indices for all farmers were arrayed by region and a series of descriptive statistics were calculated. No pattern emerged from comparisons of the several measures calculated. In terms of means, only that for Thrace differs from the other three. Even here, while adoption rates in South Marmara are clearly lower than Mediterranean and Thrace, the average index of optimism is much higher in South Marmara than in the other two regions.

Extension Variables. When the new wheat campaign was launched in 1967, few farmers or extension agents in Turkey knew about HYV's or about the agronomic practices essential for attaining high yields. At the outset, Government assigned 250 extension workers to the coastal regions for full time work in the wheat program. International agencies and experts from foreign universities also helped to diffuse the new technology.

All in all a substantial effort was made to get information to the farmers. One measure of the success of this effort is that virtually all of the farmers sampled for this study reported knowing about HYV's. Only in the Aegean Region did those reporting no knowledge of improved wheat varieties exceed 3 percent. There, some 30 percent of the sample farmers said they were not aware of such varieties.

Most of the farmers reported that their first knowledge of HYV's came from the extension service. In all regions the proportion reporting first knowledge from agricultural organizations exceeded 80 percent. This result might be partially attributable to the fact that the enumerators for this survey were extension agents.

A surprisingly large number of sampled farmers reported extension visits, from 75 percent in Aegean to 92 percent in Thrace. This might be because farmers were reporting all kinds of visits by representatives of agencies associated with agriculture. Many farmers reported participating in extension activities—from 13 percent in Aegean to 43 percent in Mediterranean. Finally, the reported knowledge of the technology and of the equipment best suited to the implementation of the technology varied from 37 percent in the Aegean to 76 percent in the Mediterranean and up to approximately 95 percent in the other two regions.

In each of the above cases the Aegean Region lagged well behind the others, and it also lags in the adoption of HYV's. But, in each case, South Marmara compared quite

well with Mediterranean and Thrace and it too lags behind in the adoption of HYV's.

Table 14 relates several dimensions of extension to the class of seed reported by sampled farmers. While clear cut patterns do not emerge from the table, adoption of HYV's usually report closer association with extension activities than do users of other varieties.

Seed availability and credit. Government influences on the production of seed dates to 1963 when a seed production and certification law was passed. Responsibility for insuring quality seed falls to State Farms. These farms produce seed and also gather the seed of contracted farmers. They inspect, clean, treat, and bag the assembled seed which is then sent to seed laboratories for testing. Seed distribution is carried on by several cooperating governmental agencies.

Seed production and sales reached 200,000 tons in 1969. From 1969 on, production has held up well but sales declined substantially to 39,000 tons in 1971. It is said that this reduction is largely due to the reduction in the availability of agricultural credit for financing seed purchases.

There is some evidence that availability of seeds is influencing adoption of HYV's. For example, in Aegean Region 58 percent of the farmers sampled expressed this difficulty and 89 percent of these did not plant HYV's. For South Marmara the comparable percentages are 56 and 92 respectively. By way of contrast while 25 percent of Mediterranean farmers reported difficulty in getting HYV's, only 18 percent of these did not plant HYV's.

A second factor which might limit the use of HYV's is the distance which farmers must travel in order to acquire the seed. For both Aegean and South Marmara, the distance to a source of HYV's is lower for adopters than for others. In the case of Aegean the comparison is 14.6 km. vs. 15.2 km while in South Marmara it is 16.9 km. vs. 28.3 km. Again, however, the pattern is made less meaningful by the average distance reported by adopters in Thrace, 19.9 km. This is considerably greater than the distance reported by non-adopters in Aegean.

Table 14. **Extension services by region and by class of seed (percent of farmers).**

Region	Seed	Extension visits	Field days, lectures, etc.	Aware of new technology
Mediterranean	HYV's	78	44	75
	Other	80	27	67
Aegean	HYV's	82	26	54
	Other	68	7	30
South Marmara	HYV's	98	33	100
	Other	84	44	91
Thrace	HYV's	93	45	96
	Other	89	15	98

Among farmers reporting the purchase of HYV's an overwhelming proportion of them paid with their own cash: over 65 percent in Mediterranean, over 80 percent in Aegean and Thrace, and over 70 percent in South Marmara. These responses may, of course, signal that tight credit is limiting the expansion in use of HYV's.

Markets. Even given the faithful and sincere efforts of the government to protect farmers from the vagaries of adverse price fluctuations, it is sometimes said that not all farmers have access to the protection offered by the government's wheat trading agency, TMO. In particular it is said that Aegean and South Marmara farmers do not find these services available and that, because of apprehension over the marketability of the red grained Mexican wheats, these farmers were reluctant to adopt improved varieties. To examine the validity of these statements two marketing variables were included in the analysis.

It is instructive to consider the relation between adoption of HYV's and sales of wheat. This is seen in Table 15. The percentages clearly present a consistent pattern with high rates of adoption and sales going together. Even so, of the farmers selling wheat, 45 percent grew local varieties in Aegean, 56 percent in South Marmara, and 20 percent in Thrace.

Data from several Aegean and South Marmara villages with low adoption rates support some interesting speculation on the influence of markets on the diffusion of HYV's. In the twelve selected villages with 122 farmers only seven farmers used HYV's. Forty-six farmers, 38 percent, sold wheat. All but one of these sold wheat to private dealers. Of the seven adopters, four sold wheat and one of these sold to TMO. This all might mean that the emphasis on private sales led the farmers to prefer local wheats over HYV's.

While the preceding conclusion is not completely consistent with the absence of price differentials reported by farmers surveyed, it does fit other data which suggest that while prices of the two wheats tend to move together, for some markets TMO does not operate for long periods. Rather, in some local markets TMO is on hand for only a few months after harvest.

Data from the survey are not, unfortunately, completely clear on the effects of markets on adoption of HYV's. More detailed field work is being carried out to clarify the role of markets in the diffusion of HYV's.

Table 15. **Percentages of sample farmers adopting HYV's and percentage reporting sales of wheat.**

	Mediterranean	Aegean	S Marmara	Thrace
Fields with HYV's	95	28	27	76
Farms selling wheat	82	33	25	78

Table 16. **Average fertilizer use on wheat by sampled farmers cross classified by farm size, region, and topography (kg N + P_2O_5 per ha).**

Region	Zone	Smaller farms	Larger farms
Mediterranean	Hillsides	125	143
	Flat lands	113	122
Aegean	Hillsides	26	59
	Flat lands	33	57
South Marmara	Hillsides	44	60
	Flat lands	57	53
Thrace	Hillsides	91	106

Table 17. **Fertilizer use on wheat by sampled farmers classified by region, topography, farm size [a], and type of seed (kg N + P_2O_5 per ha).**

		Smaller farms		Larger farms	
Region	Zone	HYV	Other	HYV	Other
Mediterranean	Hillsides	133	–	153	–
	Flat lands	114	–	124	–
Aegean	Hillsides	–	26	64	30
	Flat lands	64	16	60	27
South Marmara	Hillsides	69	41	64	42
	Flat land	80	37	65	48
Thrace	Hillsides	107	67	110	89

a/ See Table 10.

Table 18. **Fertilizer use and membership in agricultural organizations by region (kg N + P_2O_5 per ha).**

	Mediterranean	Aegean	S. Marmara	Thrace
Members	151	47	53	102
Non-members	93	22	28	53

Table 19. **Distance from farm to source of fertilizer by region and quantity used (kilometers).**

Fertilizer use	Mediterranean	Aegean	S. Marmara	Thrace
High	20.3	14.7	12.1	13.9
Low	18.5	18.3	14.9	14.5

Table 20. **Percentage of sampled farmers using fertilizers who expressed difficulty in obtaining fertilizer, by region, class of seed, and level of fertilizer use.**

Region	Seed	Low Use	High Use
Mediterranean	HYV	33	55
	Other	–	–
Aegean	HYV	30	57
	Other	41	34
South Marmara	HYV	42	50
	Other	60	74
Thrace	HYV	66	75
	Other	83	67

Fertilizer and Individual Varieties

Fertilizer use in wheat has increased dramatically in Turkey. From application of 3 percent of all wheat in 1963 it rose to 32 percent of all wheat in 1972. Subsides on fertilizers were instituted in 1963 and, until 1974, it is estimated that Turkish farmers paid some 40 percent of the production cost. Roughly, three kilos of wheat were required to buy a kilo of nitrogen. Half of the nitrogeneous fertilizers were produced domestically, half were imported. Benefit/cost ratios estimated by State Planning Organization were favorable to wheat, on the order of 3, but were even better for such crops as beets (4), beans (5), rice (10), and cotton (11).

Farm size, topography, and HYV's. Table 16 shows average use of nitrogen and phosphorus on wheat by sampled farmers. All farms are cross classified by farm size, region, and topography. The effect of region and farm size is quite clear as the farmers of Mediterranean and Thrace use far more fertilizer than these of the Aegean or South Marmara regions. With the single exception of South Marmara flat lands, larger farmers apply more fertilizer to wheat than do smaller farmers. Topography has no consistent affect on fertilizer applications as flat-land farmers sometimes use more fertilizer than do hillside farmers and sometimes the reverse.

Table 17 shows fertilizer use as influenced by type of seeds. It is clear from the table that farmers who plant HYV's, use more fertilizer on the average than do farmers who plant local varieties. The difference is consistent for all regions, topographies, and farm size groups. It is undoubtedly connected with research results which show that HYV's are more fertilizer responsive than local varieties. An unpublished State Planning Organization report shows benefit/cost ratios of 2.73 for HYV's and 1.93 for local varieties. It is also linked to credit programs which insist that recipients of credit for seed use fertilizer at recommended levels. While this stricture is probably not adhered too, it has undoubtedly had some influence.

The most arresting result from Table 17 is that for HYV's the relationship between fertilizer use and farm size, seen in Table 16, is sharply reduced when variety grown is considered. Much of the difference in fertilizer use on small and large farms appears to be related to the more widespread use of HYV's on the larger farms. Only in Mediterranean Region is the size/fertilizer relationship maintained. For local varieties, however, the size/fertilizer relationship is maintained in each of the five subregions in which appreciable quantities of local wheats are found.

One general point can be made with respect to fertilizer use and this is that only in the Mediterranean area are farmers approaching recommended levels. Recommendations are on the order of 180 kilos of nutrients—roughly 120 kilos of nitrogen and 60 kilos of phosphate—ranging from 160 kilos to 200 kilos. Contrast such recommenda-

tions with the data of the tables which show even the highest area, larger Mediterranean hillside farmers, at 143 kilos with other regions falling away sharply from that rate. Or consider the data of Table 4 which suggest that some 19 percent of Mediterranean farmers, less than 3 per-percent of Aegean farmers, less than 4 percent of South Marmara farmers, and less than 16 percent of Thrace farmers are following recommendations.

What is restraining fertilizers, whether ignorance, faulty recommendations, availability of fertilizers, or risk aversion, cannot be said. It's likely that each of these factors is contributing in greater or lesser degree to the differences between use and recommendations.

Membership. Age and education as they related to fertilizer use were not examined individually. Membership in agricultural societies was considered and the results are shown in Table 18. It is clear that members use appreciably more fertilizers than non-members in each of the four regions. This is consistent with the idea that societies, especially cooperatives, have preferred access to fertilizers and that society members have easier access to credit and to the fertilizer itself than do non-members.

Distance to source. For the most part farmers transport fertilizers from markets to farms. Only in Aegean Region is an appreciable portion transported by someone other than the farmer. There some 24 percent of the sampled farmers report other means of transportation.

Variation in distances transported vary from region to region and between those who use heavy and light applications. This variation is seen in Table 19.

In general differences are small and relate shorter distances to greater fertilizer use.

Availability and credit. While the use of fertilizer has increased dramatically since 1963, it is said that many farmers cannot obtain the fertilizer they would like to have. Table 20 relates class of seed and relative use of fertilizers to difficulties in getting fertilizers as reported by sampled farmers.

While no consistent pattern emerges from the data of Table 20 it can be said that those with greater use of fertilizer and those seeding HYV's tend to have greater proportions reporting difficulties in obtaining fertilizers.

Another classification on this same variable, i.e. farm size against difficulty in obtaining fertilizer shows that only in Aegean and South Marmara did small farmers report appreciably more difficulty in obtaining fertilizers than large farmers. For Aegean 79 percent of small farmers as compared with 76 percent of larger farmers reported difficulty while for South Marmara 63 percent of smaller farmers as compared with 44 percent of larger farmers reported difficulties.

Credit is widely used for purchasing fertilizer according to sampled farmers. This is seen in Table 21 which reports source of funds and Table 22 which shows source of credit for those using credit. The percentages related only to those who responded to the question (some 28 percent of Mediterranean farmers and 33 percent of Aegean farmers did not respond to the question while virtually all South Marmara and Thrace farmers responded).

Table 21. **Source of funds for fertilizer purchases among sampled farmers (percent)**

Region	Own funds	Credit	Combination
Mediterranean	47	36	17
Aegean	44	55	1
South Marmara	38	38	25
Thrace	44	45	12

Credit clearly played an important role in financing the purchase of fertilizers. Judging from the column "Own funds" there is not much variation among regions except that South Marmara appears to be somewhat lower than others. Of more interest is the difference in merchant financing reflected in the second part of the table. Merchants play an important role in Mediterranean Region while cooperatives dominate financing in the remaining regions.

A cross classification of farmers by size with respect to fertilizer credit showed that, among farmers using fertilizers, larger farmers tend to be more likely to use credit for fertilizers than smaller farmers. The differences are small in Mediterranean and Thrace, less than 2 percentage points, and larger in South Marmara, 21 percentage points. In Aegean Region, the relationship is reversed with 71 percent of the smaller farmers using credit for fertilizer versus 63 percent for large farmers.

Extension service. Several classes of extension services were included in the study. These and their relationship to fertilizer use are included in Table 23.

A greater proportion of those using more fertilizers reported visits from extension personnel than did those applying less fertilizer. Roughly the same pattern holds for participation in field days, lectures, and etc. as well as among those who were aware of the technology. In general, then, a greater exposure to extension services is related to greater fertilizer use.

Two aspects of the table are of interest. One is the relative awareness of new technology by South Marmara farmers. The data suggest they are more aware than farmers of other regions but their adoption rates, for vir-

Table 22. **Source of credit for fertilizer purchases among sampled farmers using credit (percent).**

Region	Agricultural bank	Cooperatives	Merchants	Other
Mediterranean	17	39	38	6
Aegean	11	89	0	-
South Marmara	11	72	1	16
Thrace	17	80	1	2

Table 23. **Participation in various classes of extension service by region and fertilizer use (percent).**

Region	Fertilizer use	Extension visits	Participated field days, etc.	Aware of new technology
Mediterranean	High	92	53	79
	Low	69	36	72
Aegean	High	67	11	52
	Low	82	8	26
South Marmara	High	95	56	99
	Low	80	26	88
Thrace	High	93	35	96
	Low	92	40	96

Table 24. **Participation in various classes of extension services by region and farm size (percentages of farmers).**

Region	Farm size	Extension visits	Field days
Mediterranean	Smaller	71	33
	Larger	86	54
Aegean	Smaller	65	11
	Larger	81	15
South Marmara	Smaller	85	40
	Larger	91	43
Thrace	Smaller	92	33
	Larger	93	41

tually all elements, are notably lower than those in Mediterranean and Thrace.

The second is the relatively low rates of exposure evidenced in Aegean Region. This conforms with their low rates of adoption of HYV's and fertilizers.

An alternative grouping vis a vis extension services is shown in Table 24. Here, exposure to extension services is cross classified by region and farm size.

As expected larger farmers fare better than smaller farmers. Again Aegean farmers, with low rates of fertilizer use and adoption of HYV's have lower percentages of participation than do farmers from other regions. South Marmara farmers, on the other hand, have high rates of participation but low rates of adoption. Mediterranean farmers, with the highest rates of adoption, tend to lag behind both South Marmara and Thrace farmers.

Other Elements of the Technology.

Looking now at other elements of the technology, data from sampled farmers have been cross classified with use of HYV's by region. The results are seen in Table 25.

Seeds distributed by state farms are virtually always treated. Seeds can also be treated by farmers with the assistance of cooperatives or other agricultural agencies. In general, and as might be expected because government agencies distribute no local varieties of spring wheat, more HYV users report seed treatment than do growers of local wheats. The proportions are quite high for South Marmara and Thrace HYV growers, notably low for Mediterranean local variety growers.

Surprisingly few farmers drill seeds. Only in Aegean Region is there any appreciable use of seed drills. In

Table 25. **Farmers reporting certain practices classified by class of seed and by agro-climatic region (percent of fields).**

Region	Seed	Treated seeds	Drilled seeds	Seeded Nov-Dec [a]	Weed control	Fertilizer hand-cast	Fertilizer split dose
Mediterranean	HYV's	61	2	94	20	98	78
	Other	21	0	10	10	100	48
Aegean	HYV's	77	5	37	25	93	67
	Other	68	1	30	12	86	5
South Marmara	HYV's	98	4	59	87	100	81
	Other	75	15	22	52	100	59
Thrace	HYV's	97	6	*b*	33	100	92
	Other	84	2	*b*	32	100	70

a/ Recommended date for varieties from Mexico. *b/* Winter wheats seeded earlier in the fall.

general more HYV users avail themselves of drills but the differences--HYV versus users of local varieties while consistent, are negligible.

Looking now at seeding date, Mediterranean HYV users are complying with the recommended seeding dates. Aegean HYV users do not seem to be doing so but there are extenuating circumstances. First, some 20 percent of the HYV's are Bezostaya and this has a different seeding date. Second, some 25 percent of those using varieties from Mexico are sowing in the spring. Thus, if all remaining HYV users were seeding at the recommended time, the percentage should be 60 percent rather than 37 percent. Why nearly half of the winter sown Mexican HYV's are not seeded at the recommended time is not evident from the data. It is likely that yields are reduced but it might also be true that risks of frost or excessive moisture at planting time is also reduced.

For South Marmara 70 percent of the HYV's are from Italy and Russia. Thus it can be inferred that all of the Mexican plus a good part of the Italian varieties are being sown in November and December. It should be pointed out that most Italian and local varieties are photoperiod sensitive hence the date of seeding is not so critical as with Mexican varieties.

HYV users consistently report more weed control than do users of other varieties, but, except for South Marmara, the differences are not large. The quite substantial difference in weed control seen in South Marmara is not readily explainable.

As with seed, most fertilizer is hand cast. What is rather surprising is that hand casting shows up relatively less among Aegean farmers. Given the use of seed drills reported in South Marmara, one would have expected South Marmara to have shown less hand casting of fertilizer than Aegean.

HYV users are more consistent in reporting split applications of fertilizers than are users of other varieties. Moreover, differences tend to be large. This is undoubtedly related to the larger applications of fertilizers reported by HYV users.

All in all, HYV users tend to be more likely to apply complementary recommended practices than are those who seed other varieties. Except for split applications of fertilizer and weed control, however, the differences are not notable.

Notes

1. The weather risk index for a given farmer is defined as $1 - (Y_b/Y_n)/(P_b/P_n)$ where Y_b and Y_n are the yields (in kg/dec.) the farmer expects in bad and normal conditions, and P_b and P_n are the probabilities the farmer assigns to bad and normal conditions.
2. A.D. Roy. 1952. "Safety first and the holding of assets," *Econometrica*, 29:431-438.
3. L.G. Telser. 1955-56. "Safety first and hedging," *Review of Economic studies*, 23:1-16.
4. S. Kataoka. 1963. "A stockastic programming model," *Econometrica*, 31:181-196.

V. MULTIVARIATE ANALYSIS OF FACTORS AFFECTING ADOPTION

In the previous chapter, we examined the relationship between adoption of HYV's, fertilizer use, and individual variables through the use of two-way tables. For several reasons, it is useful to examine the relationships using multivariate analysis. First, we can consider variables not easily considered in two-way tables. Second, multivariate analysis allows us to estimate the effect of any one variable while holding others constant. Finally, we are able to compare more directly the effects of each of the variables being considered.

Two types of analytical techniques, ordinary least squares regression analysis and logit analysis, are employed in relating several independent variables to the adoption of HYV's and to the application of fertilizers. The statistical properties of ordinary least squares are reasonably satisfactory for analysis of the amount of fertilizer applied and this technique was applied to that relationship. Ordinary least squares can, however, be quite unsatisfactory for the analysis of a dichotomous variable such as the adoption of HYV's.

Nerlove and Press[1] discuss the problems involved in applying ordinary least squares to relationships featuring a dichotomous dependent variable. They go on to offer logit analysis as an alternate technique. In this study both

Table 26. **Description of variables used in regression and logit analysis of adoption decisions.**

Independent variables	
Age:	Farmer's age; in years.
Education:	Farmer's education; codes from 1 (no formal education) to 7 (college).
Family size:	Number of family members dependent on farm
Membership:	Membership in agricultural society; 1 if member, 0 if not.
Radio:	Number of times per month the farmer listens to agricultural radio programs.
Off-farm work:	Off-farm work by farmer; number of days per year.
Other income:	Off-farm income by members other than farmer; 1 = yes, 0 = no.
Weather risk:	An index of farmer's assessment of weather risk (see text), smaller values representing more risky assessment. (Index values range from 0.07 to 6.0).
Farm size:	Total farm size; in hectares.
pct wheat:	Percent of farm allocated to wheat
Field distance:	Distance between home and fields, in kilometers.
Owner:	1 = Land was owned, 0 = not owned.
Tractor:	1 = Tractor is used, 0 = not used.
Valley:	1 = Valley farm, 0 = foothill or hillside farm.
Sells wheat:	1 = Farmer sells wheat, 0 = does not sell any wheat.
Government:	1 = Farmer sells wheat to government, 0 = does not sell to government.
Fert. Avail.:	Availability of fertilizer; 1 = is not difficult; 0 = is difficult.
Seed avail.	Availability of seed; 1 = was easy to obtain, 0 = was not.
Extension:	Farmer participation in field days, lectures, demonstrations; 1 = yes, 0 = no.
Dependent variables	
HYV adoption:	Adoption of high-yielding variety; 1 = yes, 0 = no.
Fertilizer:	Nutrients applied ($N + P_2O_5$); kg/ha.

techniques were applied to the HYV adoption data.

In presenting results, logit coefficients have been converted to direct probability estimates so as to be comparable to the ordinary least squares estimates. In each case, the coefficients presented are to be interpreted as the change in the probability that a farmer will adopt HYV's as a result of a one unit change in the independent variable.

We assume that the logit coefficients are the better of the two sets of estimates. Only in the case of South Marmara are notable differences evident. There it appears that ordinary least squares underestimates the impact of several of the independent variables.

Several variables in addition to those discussed in the previous chapter were included in the following analyses. A description of all variables is given in Table 26.

Factors Affecting Adoption of HYV's.

We first present the general nature of the results of the analysis of adoption decisions, then procede to discuss them in more detail. We shall speak of a variable as having an important effect if it is estimated with reasonable accuracy and if its effect on the probability of adoption is notable. Reasonable accuracy in estimation is defined here as a logit *t*-ratio of at least 1.0 in absolute value. A notable effect is defined as an increase of 10 points or more in the probability of adoption when (a) a continous independent variable changes from its value at the 15th percentile to its value at the 85th percentile in its sample distribution, or (b) a dichotomous variable is increased from a value of zero to a value of 1.0. Since about 95 percent of the farmers in the Mediterranean Region were using HYV's, that region was not included in the analysis. The regression and logit coefficients for the three remaining regions are shown in Table 27. Discussion is based on logit results.

Of the farmer characteristics considered, for important variables, education and the index of weather risk have the greatest effects on the adoption decision, changing the probability of adoption by 10 to 20 percent and 18 to 28 percent, respectively. The size of the family is consistently positive but in only one case, that of S. Marmara, is it important with an increase of five persons increasing the probability of adoption by about 10 percent. Of the farm characteristics, topography was the most influential, with valley farms more likely to adopt by 35 percent in Aegean and Thrace. Farmers who sell wheat were from 9 to 18 percent more likely to adopt than were those who did not. Of the three government policy variables considered, seed availability is important in all regions with an effect of 32 to 51 points. Sales to government had a notable effect, ranging from 17 to 21 points, and with *t*-ratios just at or above 1.0 in all cases.

Farmer characteristics. As was suggested by the analysis of the previous chapter, education is an important factor in determining whether or not a farmer adopts HYV's. Each unit increase in education increases the probability of adoption by from 3 to 5 percent. This is presumably a result of an increasing knowledgeability of the value of HYV's, and an increasing ability to make use of this knowledge. Family size also had a positive effect on the probability of adoption, with each additional person increasing the probability of adoption by 1 to 2 percent. This was not anticipated, and we can present no rationale which could explain this positive (though small) relationship.

Farmer perception of risk, as reflected in the weather risk index, had the anticipated effect on adoption in S. Marmara and Thrace, but not in Aegean. Given the range of indexes found among farmers, differences in risk perception (two standard deviations) affect the probability of adoption by 28 percent in S. Marmara and by 18 percent in Thrace. An inexplicable negative relationship was found in Aegean, however, indicating that the more risky the farmer perceived

Table 27. **Regression and logit analyses of the adoption of high-yielding varieties.** [a]

Variable	Aegean regression	Aegean logit	S. Marmara regression	S. Marmara logit	Thrace regression	Thrace logit
Constant	−0.17		−0.27		−0.54	
Age						
coefficient	−0.0002	−0.0035	0.0009	0.0025	0.0011	0.0018
t-ratio	−0.1	−0.9	0.4	0.6	0.4	0.6
Education						
coefficient	0.046	0.050	0.049	0.072	0.035	0.029
t-ratio	2.0	1.7	2.4	2.1	1.2	0.9
Family size						
coefficient	0.0098	0.015	0.013	0.021	0.010	0.015
t-ratio	1.0	1.1	1.1	1.1	0.8	0.9
Membership						
coefficient	0.027	0.045	0.076	0.042	0.053	0.044
t-ratio	0.5	0.6	1.1	0.4	0.4	0.4
Radio						
coefficient	−0.0083	−0.0057	0.0089	0.013	0.0034	0.0017
t-ratio	−1.4	−0.7	1.6	1.3	0.6	.3
Off-farm work						
coefficient	0.0002	0.0002	−0.0006	−0.0008	0.0000	0.0001
t-ratio	0.5	0.3	−1.2	−0.8	0.2	0.3
Other income						
coefficient	−0.053	−0.12	−0.048	−0.059	0.075	0.161
t-ratio	−0.8	−1.2	−0.7	−0.5	0.6	0.9
Weather risk						
coefficient	−0.056	−0.18	0.091	0.14	0.37	0.36
t-ratio	−0.9	−0.9	3.7	2.4	2.0	1.5
Farm size						
coefficient	0.0090	0.0092	0.0005	−0.0019	0.0012	0.0018
t-ratio	1.5	1.4	0.1	−0.3	0.5	0.6
Percent wheat						
coefficient	−0.0010	−0.0012	−0.0002	0.0004	0.0028	0.0035
t-ratio	−0.8	−0.7	−0.1	0.2	1.8	2.0
Owner						
coefficient	0.12	0.15	−0.05	0.072	0.085	0.10
t-ratio	1.2	0.7	−0.5	0.4	0.7	0.8
Tractor						
coefficient	−0.025	−0.022	0.16	0.28	0.098	0.090
t-ratio	−0.4	0.3	3.0	2.7	1.3	1.1
Valley						
coefficient	0.34	0.34	0.059	0.045	0.35	*c*
t-ratio	5.3	3.7	0.9	0.4	2.3	
Sells wheat						
coefficient	0.095	0.089	0.069	0.11	0.18	0.18
t-ratio	1.4	1.0	1.1	1.1	2.2	2.0
Government						
coefficient	0.10	0.17	.21	*b*	0.17	0.19
t-ratio	0.8	0.9	1.1		2.4	2.0
Seed availability						
coefficient	0.37	0.33	.41	0.51	0.33	0.32
t-radio	5.4	3.6	7.6	4.9	5.1	4.3
Extension						
coefficient	0.19	0.11	−0.07	−0.15	0.11	0.15
t-ratio	2.2	1.2	−1.2	−1.4	1.7	1.8
Number of farms	153	153	176	176	178	178
R^2	0.61		0.60		0.36	
Chi-square		69.4		86.1		142.0

a/ Since the regression results are from ordinary least squares analysis of a dichotomous dependent variable, the t-ratio cannot be used for tests of hypotheses. The logit coefficients presented are the probability transformation of the logit model coefficients, i.e. the change in probability of adoption given a one-unit change in the independent variable. They are therefore directly comparable to the regression coefficients. The

t-ratios for the logit coefficients are those corresponding to the estimated coefficient of the logit model itself.

b/ In South Marmara, all four farmers who sold grain to the government were also adopters, and the logit procedure does not permit estimation of a model including this variable.

c/ In Thrace, all seven valley farmers were also adopters, and the logit procedure does not permit estimation of a model including this variable.

wheat to be, the more more likely he was to adopt HYV's. Given that the risk from frost and drought in S. Marmara is quite similar to that in Aegean, this difference in farmer behavior is not easily explained.

Farmer membership in agricultural societies was estimated to increase the probability of adoption by about 4 percent in all three regions, but this is a small effect, not significantly different from zero. The effects of the other farmer characteristics, age, radio listening, off-farm work and other income, were so small or so inconsistently estimated as to be deemed negligible.

Farm characteristics. Each of the farm characteristics considered was important in influencing farmer adoption decisions in at least one of the areas. The most important of these factors was topography in Aegean and Thrace, with flat-land farmers about 35 percent more likely to adopt, other factors constant. The effect of topography appears to be much less in S. Marmara, and since this was not suggested by the data of Table 11, this result bears some scrutiny. The simple correlation between adoption and topography was about 0.30, which is considerably lower than in the other two regions, but still substantial. The low estimate of topographic effect in S. Marmara may be due to the very high correlation between flat land farmers and high high weather risk indexes (correlation = 0.4). If most farmers with high (optimistic) weather risk perception live in the flat lands and if most adopters also live in the flat lands; it can be very difficult to determine which factor, weather risk or topography, is most closely related to the decision to adopt. Since the estimated effect of weather risk in S. Marmara is the largest of the three regions, and the estimated effect of flat lands is the smallest, it is quite plausible that the estimation procedure is overestimating the former and underestimating the latter in S. Marmara, due to the correlation between the two.

The second most influential characteristic of the farm is whether or not wheat is marketed. Those farmers who sell wheat are estimated to be more likely to adopt HYV's by 9 percent in Aegean, 11 percent in S. Marmara, and 18 percent in Thrace. This suggests that any market discounts which might exist for HYV's do not adversely affect the decision to adopt, contrary to the inferences tentatively drawn in the previous chapter (though we have more to say in this below).

Farms with tractors appeared to be significantly more likely to adopt HYV's in S. Marmara and Thrace, though not in Aegean. The size of the effect in S. Marmara (28 percent) is surprisingly large, particularly when compared to the estimates for the other two regions. As with the case of the effect of topography mentioned above, if the tractor variable is correlated with any other variables, the estimation procedure may attribute too much effect to the tractor variable and too little to one of the others. The other variables which were correlated with tractor use were wheat sales (0.25), weather risk (0.25), education (0.21), topography (0.17) and farm size (0.15). Of these, only the effects of topography and farm size appear to be underestimated compared with the other regions, so it is possible that some of the effect attributed to tractor use in S. Marmara is actually attributable to valley topography and larger farm size among the farms using tractors.

The impact of farm ownership was not estimated with great precision but the effect is to increase the probability of adoption (by about 10 percent) as expected. The percentage of cropland devoted to wheat had no effect on the adoption decision except in Thrace, where each additional percent of wheat increased the probability of adoption by one-third of a percent. Farm size appeared to be an important factor only in Aegean, where each additional hectare of farm size increased the probability of adoption by nearly 1 percent. While this would have a considerable impact for extremely large farms of 100 hectares or so, the distribution of farm sizes in Aegean was such that a farm at the 98th size percentile (about 17 ha) would be only about 10 percent more likely to adopt than an average sized farm (about 6 ha).

Government policy. Three factors related to government policy were considered: whether or not the farmer sold to the government purchasing agency, whether or not HYV seed was easy to obtain, and whether or not the farmer had participated in field days, lectures, or demonstrations. Of these, seed availability had the most important effect. Those farmers who said that seed was easy to obtain were 32 to 51 percent more likely to have adopted HYV's than those who said it was not easy to obtain. This factor appears to have the greatest impact on farmer decisions of all the variables considered in this analysis. This result should be interpreted with some caution, however, since it is in general true that seeds will be easier to obtain where the HYV's are well adapted, and more difficult to obtain where they are unadapted. Thus this variable could be serving as a proxy for the adaptability of the HYV's. This

could be happening in the S. Marmara estimates, for example, where the effect of seed availability is high relative to other estimates, and the estimated effect of flat land is relatively low, as previously mentioned.

The effect of sales to the government marketing agency TMO, was to increase the probability of adoption by about 20 percent in all three regions. This bears out previous observations that the HYV's are more saleable on the government market than on the private market. The effect of extension activities was positive as expected in Aegean (11 percent) and Thrace (15 percent), but was negative in S. Marmara. One would not normally expect that participation in a field day would reduce the probability that a person would adopt a new variety, yet this conclusion is supported by the data of Table 14. Again, however, it is possible that extension activity has been more intensive in areas where the HYV's were less-well adapted, while other variables in the analysis (such as topography) have failed to reflect differences between these areas.

Summary. The results of the multivariate analysis of HYV adoption decisions have shown that topography, presumably representing the adaptability of the HYV's, seed availability and government purchasing activities have been the most important variables affecting the adoption decision among the farmers studied. In addition, education, family size, wheat sales, and land ownership had smaller but consistently estimated effects in the expected direction. In two of the areas, the effect of perceived weather risk had an important effect on the adoption decision, and two others, participation in extension activities had a significant impact in increasing the probability that a farmer would adopt HYV's. The estimates of the effects of several of the variables in S. Marmara were inconsistent with estimates for the other areas, perhaps due to correlation among the variables or to poor specification of the variables in this area.

Factors affecting application of fertilizers.

Again, the general nature of the results are presented first, followed by more detailed discussion. A variable is said to be having an important effect if it is estimated with reasonable accuracy and if its effect on fertilizer use is notable. Reasonable accuracy in estimation is defined here as a *t*-ratio of at least 1.0 in absolute value. A notable effect is defined as an increase of 15 kilos of plant nutrients per hectare when (a) a continuous independent variable changes from its value at the 15th percentile to its value at the 85th percentile in its sample distribution, or (b) a dichotomous variable is increased from a value of zero to a value of 1.0. Regression results for all four regions are given in Table 28.

Of the farmer characteristics considered, membership in agricultural societies is the only variable which consistently has a *t*-ratio greater than one. Moreover, in the cases of Mediterranean and Thrace regions, where fertilizer use is greatest, membership is important in the sense described above. Listening to the radio is important in three regions but, awkwardly, not in a consistent way. Age has appro-

Table 28. **Regression analyses of the use of fertilizer by region.** *a*

Variable	Mediterranean	Aegean	S. Marmara	Thrace
Constant	33.0	0.13	30.0	48.0
Age				
Coefficient	-0.05	0.13	-0.30	-0.53
t-ratio	-0.1	0.6	-1.1	-1.7
Education				
Coefficient	0.09	0.99	-3.3	-4.8
t-ratio	0.1	0.5	-1.4	-1.5
Family size				
Coefficient	-1.6	2.3	-0.21	0.40
t-ratio	-1.3	2.5	-0.2	0.3
Membership				
Coefficient	43.0	7.5	8.6	57.5
t-ratio	4.5	1.4	1.1	4.0
Radio				
Coefficient	-0.83	0.46	0.95	-1.9
t-ratio	-1.1	0.8	1.5	-3.2
Off-farm work				
Coefficient	0.06	0.041	-0.011	0.07
t-ratio	1.2	1.0	-0.2	1.7
Other income				
Coefficient	12.0	-18.0	-1.9	-15.0
t-ratio	1.4	-2.8	-0.3	-1.0
Weather risk				
Coefficient	12.0	-0.29	-0.43	64.0
t-ratio	2.0	-0.1	-0.1	3.2
Farm size				
Coefficient	0.19	-0.045	-0.57	0.12
t-ratio	0.9	-0.1	1.9	0.4
Percent wheat				
Coefficient	0.38	-0.06	3.6	-27.0
t-ratio	2.7	-0.5	0.3	-1.5
Field dist.				
Coefficient	0.06	0.65	0.99	0.33
t-ratio	0.2	2.6	3.2	0.8
Owner				
Coefficient	0.53	3.2	0.67	-8.4
t-ratio	0.1	0.3	0.1	-0.6
Tractor				
Coefficient	39.0	0.50	4.1	4.1
t-ratio	2.4	0.1	0.7	0.5
Valley				
Coefficient	13.0	-4.5	-3.3	32.0
t-ratio	-1.6	-0.7	-0.4	1.8
Sells wheat				
Coefficient	0.50	6.2	24.0	23.0
t-ratio	0.1	0.9	3.3	2.7
Fert. Avail.				
Coefficient	-33.0	11.0	5.5	12.0
t-ratio	-4.0	2.0	0.8	1.5
Extension				
Coefficient	12.0	4.7	26.0	-4.5
t-ratio	1.5	0.6	4.0	-0.6
HYV adoption				
Coefficient	15.0	27.0	21.0	28.0
t-ratio	1.2	3.7	2.7	3.3
R^2		0.43	0.36	0.33

a/ Fertilizer use is expressed in kg of N and P_2O_5 per ha.

priate t-ratios in three cases but associated quantity changes are small.

Characteristics of the farm had no consistently important effects. Distance to the field is important in two cases "Sells wheat" appears to be important in South Marmara and in Thrace.

Of the three policy related variables, only fertilizer availability has appropriate t-ratios in three regions; even so, the signs are not consistent and in only one case does the increase in fertilizer use associated with changing the value of the independent variable from zero to 1.0 exceed 15 kilograms of nutrients per hectare.

Adoption of HYV's is consistently important, even in the Mediterranean region where some 95 percent of the farmers had adopted HYV's. It should be acknowledged that results from models with HYV's are less easy to interpret than were this variable not included because HYV use itself is held to be a function of the remaining included independent variables.[2]

Farmer characteristics. Of the eight variables describing farmer characteristics, only three ever manifest importance in the sense described above, viz. membership—in Mediterranean and Thrace, radio—in South Marmara and Thrace, and weather risk—in Mediterranean and Thrace. Each of the estimated coefficients for membership has the expected sign, which is to say that membership in a society is associated with greater use of plant nutrients. The size of the effect in this analysis is smaller than is implied by the data of Table 18. In the case of radio, the signs of the relevant coefficients are negative in two regions, the opposite of what was expected.

For two regions the estimated coefficients for age had t-ratios in excess of 1.0 and each had the expected sign. In no case, however, is the impact on quantity of nutrients a large one.

Off-farm work is the only remaining farmer variable for which signs tend to be consistent among regions and with expectations. For three regions, the estimated coefficients have a positive sign.

One variable manifests consistency among regions but its sign is contrary to what was expected. For all but the Mediterranean region the sign for the estimated coefficient of other income is negative and it was hypothesized to be positive. A rationable for this result is not evident.

For three variables—education, family size, and weather risk—the signs of the estimated coefficients are half positive and half negative. Only weather risk is ever important in the sense defined, in both cases positively. It might be argued that the negative sign estimated for education in Thrace is consistent with expectations, given the data of Table 5 which suggests that high rates of fertilizer application don't pay for farmers there. Table 5, which is based on farmer's reported yields, is not consistent with the rates of fertilizer application reported for Thrace in Table 16. As it seems likely that reported rates of application are more nearly correct than are reported yields, the data of Table 16 seem more reliable than those of Table 5. This conclusion puts in doubt the negative sign for education in Thrace, seen in Table 28.

Farm characteristics. Six variables describe characteristics of the farm. Two of these, tractor and topography, are important in one region and with the expected positive sign. Distance to fields is important in two regions but with different signs.

For each of the four regions use of tractor for plowing and rates of plant nutrients applied are positively related. Only in one case is the t-ratio greater than 1.0. Topography also shows consistency among regions but there, for three regions, the sign of the estimated coefficient is negative, the reverse of what was expected. This result is consistent with the data of Table 16. Distance to field is also consistent but is positive in all cases, the reverse of what was expected.

Tenure status tends to have a consistent sign with nutrient use positively related to ownership in three of the four regions. Never, however, is the t-ratio in excess of 0.6 in absolute value.

For each of the remaining variables, farm size and percent of farm area in wheat, two regions show positive coefficients, two show negative coefficients. This suggests that the positive effects of farm size on fertilizer use in Table 16 are due to the other factors which are not controlled there but are considered explicitly in the regression analysis.

For two of the regions, selling wheat is an important variable and in both cases the estimated coefficient has the expected positive sign. For all four regions the sign of the estimated coefficient is positive.

Government policy. Fertilizer availability, which emerges from asking the farmer whether or not he found fertilizer easy to obtain, is positively related to fertilizer application in three regions. In only one region, Mediterranean, is the variable important but the sign is negative, indicating that difficulty in acquiring fertilizer is positively related to its use.

For the extension variable, three regions show the expected positive sign. The variable is important in only one region, South Marmara.

Summary. In a general way the regression analyses of Chapter V conform quite well with the tables of Chapter IV. In only two cases, farm size and membership, do coefficients of the regression models depart notably from expectations based on the simpler tables in Chapter IV.

Only five of the variables are entirely consistent from region to region and with expectations as regards signs; membership, field distance, sells wheat, tractor and use of HYV's. On the other hand, six variables—farm size, radio education, weather risk, family size, percent in wheat—show great inconsistency with half being positive and half negative. Of the remaining seven variables, other income and topography show tendencies contrary to those expected.

No region stands out as peculiar, which was the case for South Marmara in the analysis of HYV adoption. Even in

terms of the number of t-ratios with absolute values greater than one, there is startling consistency with no region having notably more or notably less such estimates.

What is disconcerting in all of this is the size of the coefficients of determination. Within regions the models explained only a small part of the variation, from 33 to 43 percent. While such results are not uncommon in work of this kind, it nonetheless suggests that the prudent will be cautious in drawing conclusions. In better specified models, it might well occur that variables with little importance here would be found important.

Having recognized the constraint imposed on interpretation by the low coefficients of determination, it can still be said that regional differences in fertilizer use are notable, tending to following the pattern of the adoption of HYV's, i.e. ranking regions by percent of land in HYV's is entirely consistent with ranking them in terms of average application of plant nutrients. Even within regions, this relationship holds up. Other variables with a notable and consistent association with fertilizer use are availability of fertilizer and membership in agricultural societies. Each says something about access to fertilizers or about access to credit or both.

Notes

1. Marc Nerlove, and S. James Press. 1973. *Univariate and Multivareate Log-Linear Logistic Models,* The Rand Corporation, Santa Monica, California.

2. A more desireable econometric approach would be to estimate the fertilizer decision equation and the hybrid decision equation together using simultaneous equation techniques.

VI. SUMMARY OF FINDINGS AND POLICY IMPLICATIONS OF THE STUDY

Wheat is the most important single element in the diet of the Turkish family. Annual per capita consumption varies between 160 and 225 kilograms of grain. If the present per capita consumption is to be maintained, wheat production must increase by 2.6 percent per annum just to equal population growth rate. Moreover, this will have to be accomplished through yield increases rather than area expansion since no unused land is available in the country.

With the object of obtaining higher yields per unit area, the government of Turkey introduced in 1967 to the coastal regions new packages of wheat production techniques consisting of high yielding seed, chemical fertilizer, weed control, and several other agronomic practices. The new seeds came from Mexico, Italy, and Russia. They respond well to fertilizer and other production practices and produce high yields under favorable climatic conditions.

The purpose of this study was to look closely at the adoption of the new wheat technology, emphasizing high yielding seeds and chemical fertilizers. The specific objectives of the study were to see to what extent farmers have adopted to the new wheat seeds, applied chemical fertilizers to wheat and followed other agronomic practices recommended to them, to identify and quantify association between adoption of HYV's and fertilizer and selected factors related to the farmer, the farm and government policy, and to examine the extension system, credit and input supply situation, and market conditions as they relate to the adoption of new wheat technology.

To carry out these objectives, the study draws heavily on data obtained through regional samples consisting of 800 farms with different characteristics. The regions under study are: Mediterranean, Aegean, and South Marmara, all spring wheat regions, and Thrace, a winter wheat region. In this section we review the findings of this study, point out policy implications and suggest recommendations for the attainment of further diffusion of the new wheat technology and of higher levels of wheat production.

Findings

What follows are general comments. More specific statements are found in Chapter 5.

Between 1967 and 1972, the HYV's covered an area of about 900,000 hectares in the three coastal spring regions, Mediterranean, Aegean and South Marmara. This is around 65 percent of the land planted in wheat (including durum wheat) in these three regions and corresponds to 46 percent of all wheat fields in the regions. In Thrace, the winter wheat region, HYV's are estimated to have covered

about 290,000 to 300,000 hectares of land in 1972. This accounted for 75.7 percent of the wheat land found in the region.

So far as the coverage by specific varieties are concerned, in the three coastal spring wheat regions, Mexican varieties were grown more extensively than any others. They accounted for more than 80 percent of all high yielding varieties in terms of both the number of fields and the area occupied. The remaining 20 percent was in Italian and Russian varieties. Among Mexican varieties, the variety "Pénjamo-62" covered over 70 percent of the area. The winter wheat region, Thrace, is predominantly under the Russian high yielding variety Bezostaya.

Differences in adoption rates among regions are large. In Mediterranean, 95 percent of the wheat fields or 97 percent of the wheat land was under HYV's and of these almost all were Mexican varieties. In South Marmara, 26 percent of the wheat fields, or 40 percent of the wheat land was covered by HYV's. HYV's consisted of Italian, Mexican, and Russian varieties in roughly equal proportions. In Aegean, 29 percent of the wheat fields or 35 percent of the wheat land was under HYV's of which Mexican varieties account for more than three fourths. In Thrace, 76 percent of the wheat fields or 79 percent of the wheat land was occupied by HYV's of which Bezostaya accounts for the total.

Use of chemical fertilizers in wheat production has increased with the introduction of HYV's. As of 1972, an estimate of 100,000 tons of chemical fertilizer (net nutrients $N + P_2O_5$) was used for HYV's in the three coastal spring wheat regions. To this should be added around 30,000 tons used on Bezostaya in Thrace. The total of 130,000 tons gives an estimated 35 percent of total chemical fertilizer used in all wheat production in the country. The per hectare use of fertilizer on HYV's is considerably higher than on local varieties. However despite the higher levels, fertilizer doses are below the recommendations. If 180 kg/ha is taken as the amount recommended to farmers for HYV's, the average applied by Mediterranean farmers on HYV's was three-fourths of this. Averages were roughly one-third in South Marmara and Aegean. For Thrace the average is about two-thirds as recommendations are less than 180 kg/ha. Thus, among regions, fertilizer application in HYV's was on the average much higher in Mediterranean and Thrace than Aegean and South Marmara.

Other agronomic practices were generally not in line with the recommendations. Drill use for both seeding and fertilizer applications was virtually absent. Incidences of wheat irrigation were extremely low. Percentages of fields which had weed control were lower than was expected.

So far as differences in yields are concerned, HYV's were thought by farmers to be superior to local varieties under similar conditions. The data suggest that under any given type with equal amounts of fertilizer and with no irrigation, HYV's yielded 5 to 65 percent more than local varieties in 1971-72. Yields of HYV's were higher than local varieties even on sloping lands. Yields on flat lands under the same treatment were generally and significantly higher for both HYV's and locals as compared with yields on sloping lands.

Wide differences in adoption rates of HYV seeds and fertilizer application found among regions support the hypothesis that agro-climatic conditions are significant factors explaining adoption of the new wheat technology. Higher and more evenly distributed rainfall, lower probabilities of frost and less disease occurences have significantly contributed to higher levels of adoption of HYV spring wheats in Cukurova as contrasted to other coastal regions.

Farmers' perceptions about risk and uncertainties related to natural conditions are found to be significantly associated with adoption. Adopters are, in general, more optimistic about their probability expectations of normal and good weather conditions than non-adopters.

Fertilizer use has generally been lower than recommendations as mentioned above. Factors accounting for this are presented below.

The hypotheses that allocation of fertilizer to wheat production is negatively affected by shortage of fertilizer and competitive demand for fertilizer by relatively high-valued and more fertilizer-responsive cash crops grown in the regions such as cotton, rice, sugarbeets, vegetables, beans, etc. receive ample support from the data at hand. Due to lack of irrigation and other complementary inputs and inadequate agronomic practices, wheat cannot respond to fertilizer sufficiently to compete for fertilizer with cash crops grown under irrigation. Even so a substantial portion of all fertilizer is devoted to wheat.

Members of cooperatives, associations, etc. are found to use more fertilizer on wheat than non-members. Members apparently have less difficulty in obtaining fertilizer and credit for fertilizer, and more access to the information on new farming techniques.

Policy implications

The dry lands of middle and eastern Turkey are the major wheat production areas of the country. Wheat will continue to be one of the main crops in the coastal regions as well for several reasons. First, wheat is the country's basic food grain and its utilization continues to increase. The coastal regions have the potential to increase yields through the use of biological inputs and intensified practices. Second, wheat is a good rotational crop in flat land along with cotton, edible pulses, vegetables, etc. Third, the poorer lands of the hillsides of the coastal regions are not suitable for cotton, pulses, vegetables or other cash crops. Here, wheat along with other grains and with tobacco in some locations, fits the conditions well.

Against this background, it seems likely that the State will continue efforts and motivation to further diffuse new wheat technology. Some modifications in technology may

occur. Modifications may involve replacement of the weaker varieties, and alterations of some of the recommendations to fit farmers' conditions. It is reasonable to believe that the State's leadership and constant motivation were the overall pushing mechanism for the successful diffusion observed in the relative short period of 6 years. This should continue to be so with a renewed spirit for the years ahead for further progress.

There are still much potential gains from the new wheat technology from which the country can benefit. First, the presently available wheat area in the coastal regions is more than 1.7 million hectares. Contrasted to this the HYV's had covered 0.9 million hectares of land. Therefore, further area expansion of HYV's is feasible. Second, yields expected from HYV's may run as high as 5 to 6 tons per hectare. Turkish farmers have realized 40 to 60 percent of this potential on the average. With appropriate farming practices farmers can also reach 4 to 5 tons of grain per hectare.

Research must be given priority in the overall efforts by the state. Research in breeding for new varieties can be speeded up through provision of more resources and motivation. Along with this, agronomic research, relatively neglected in the recent past, should be given more emphasis than before. While the objectives with breeding should continue to aim higher at yields with disease resistance, frost escape and yield stability, the quality factor must also receive equal recognition. The new seeds must appeal to farmers' preferences in terms of color, size and bread making quality. This is especially important for small farmers who produce for the family's consumption. Furthermore, varieties to fit conditions prevailing at specific locations are needed. Wide differences in adoption rates of HYV seeds among regions and subregions clearly indicate that agro-climatic conditions existing in different locations are decisive factors along with others on the extent of adoption and diffusion. Thus it seems an appropriate strategy in biological research to develop several varieties for the several different kinds of regions.

To make use of the maximum yield potential from the new seeds, timely and proper seeding is necessary. In addition, adequate amounts of fertilizer should be used along with weed and disease control. Seedbed must be prepared properly and drill use should be encouraged. All these practices have, however, their costs and benefits which must be determined accurately. Agronomic research, therefore, should aim for recommendations on rates, depth, and time of seeding and fertilization. Moreover, research should supply information about the effects on yield levels of different topographies, number and timing of irrigations, weed control, drill use for seeding and fertilization.

As the findings suggest, farmer's membership in an agricultural organization is associated with higher rates of adoption. Therefore more and wider membership in agricultural organization, such as agricultural supply cooperatives, might have a positive impact on adoption of seeds and use of other inputs.

Extension services can be strengthened. More and persuasive extension visits, demonstration plots, field days, lectures can have an important bearing on the rate of adoption. However, the whole system of extension seems to be under-utilized. It can be mobilized through the provision of resources and motivation. It should be emphasized also that extension workers should be supplied by the research workers and scientists with the precise information about the new wheat technology before they are sent to the farmers.

The situation in the market can affect adoption. Farmers should be given the feeling that they are guaranteed easily accessible markets for their wheat. This could be done by increasing the number of state purchase offices and by locating them properly in their regions.

The farmer should be supplied constantly and periodically with certified seeds of reliable quality. Constraints on the timely distribution of good seeds and seed credit should be removed. Perhaps one of the alternatives would be to leave the production of seed to state farms and contracted farmers as before, but leaving the seed control and distribution entirely in the hands of farmers' organizations. In addition, state farms located in the coastal regions should be equipped and directed to provide constant flows for farmers' use.

Any increase in fertilizer use on wheat appears to be made difficult by economic reasons. With a shortage of fertilizer supply, farmers as well as the country as a whole would seek ways to use fertilizer economically. Wheat then has less chances of receiving fertilizer than cash crops in coastal regions given 1975 relative prices and productivity gains. However, as farmers are induced to use the complete package of the new wheat technology and as output prices are balanced by the State, then wheat may well become an effective competitor for fertilizer against other crops. In any event, the overall supply of fertilizer will have to be increased to reduce the competitive use among several crops.

Again, as in the case with seeds, membership in agricultural organizations would help increase fertilizer use in wheat. Perhaps efficient and timely distribution of fertilizer could be maintained by assigning the job of distribution to farmers' organizations with some control by the state.

Simple calculations indicate that if all traditional varieties are replaced by HYV's and if modest yield level of 2 to 2.5 tons can be reached, then the three coastal regions alone would supply almost one third of the nation's needs from the existing amount of land, i.e. without pressure on lands planted to other crops in the regions. To achieve those aims will require new motivation and leadership.