Staff Paper Series

Staff Paper P70-9 June 1970

WHEAT PRODUCTION IN TUNISIA: TRENDS AND VARIABILITIES

By

J. D. Hyslop and R. P. Dahl

Department of Agricultural Economics

University of Minnesota
Institute of Agriculture
St. Paul, Minnesota 55108

Staff Paper P70-9 June 1970

WHEAT PRODUCTION IN TUNISIA: TRENDS AND VARIABILITIES

J. D. Hyslop and R. P. Dahl

Republic of Tunisia
Ministry of Agriculture
Agricultural Development Division
Bureau of Economic Studies

WHEAT PRODUCTION IN TUNISIA:

TRENDS AND VARIABILITIES

by

J. D. Hyslop and R. P. Dahl

Agricultural Economics
Research Report No. 1

June 1970

This Staff Paper is an English translation of a report published in French by the Bureau of Economic Studies, Ministry of Agriculture, Republic of Tunisia.

WHEAT PRODUCTION IN TUNISIA:

TRENDS AND VARIABILITIES*

J. D. Hyslop and R. P. Dahl**

INTRODUCTION

Wheat is the most important commodity in the agricultural economy of Tunisia. During the past decade, about one-third of the arable land in the country has been planted to wheat which accounts for about one-fifth of the total value of the nation's agricultural production.

Indications are that wheat yields in Tunisia are extremely variable from year to year. This is mainly attributable to the severe environmental conditions under which wheat is produced. Rainfall is low over much of the country and extremely variable both within and between crop years.

The Government of Tunisia is currently devoting high priority to increasing wheat production through the introduction of new wheat varieties and the application of science and technology to wheat farming.

The purpose of this study is to analyze with simple statistical tools trends and variabilities in Tunisian wheat production over time. Such an analysis will be helpful in identifying the influence of environmental factors on wheat production. In addition, it can form the basis for the identification of wheat production policy issues requiring further economic analysis.

THE WHEATS OF TUNISIA

Durum (blé dur)

Durum wheat (*Triticum durum*) is the most important wheat, in terms of quantity, produced in Tunisia. Durum is widely cultivated throughout North Africa, from Egypt to Morocco. Its origin has been assigned to Ethiopia[1/] and is probably derived from Emmer (*T. dicoccum*) which is

---

* The research reported in this study was carried out in Tunisia and supported by USAID contract AID/Afr - 469.

** J. D. Hyslop is Research Associate and R. P. Dahl is Chief of Party, University of Minnesota in Tunisia.

1/E. C. Curwen and G. Hatt, *Plough and Pasture*, New York, Collier Books, 1961, pp. 20-31.

known to have been cultivated in Egypt from prehistoric periods to the beginning of the Christian era.2/

In the United States, durum is classed as a spring wheat, planted in the spring for harvest in August. More than 85 percent of the U.S. production comes from North Dakota, and most of this from a three-county area known as the "Durum Triangle". In Tunisia, durum is seeded in the late fall to take advantage of the winter and spring rains. It is harvested in early summer.

To the market, durum wheat is a unique commodity. It is used primarily for pasta products, macaroni and spaghetti, and in these products it has no really good substitutes. In Tunisia, it is also the preferred raw material for couscous, a staple in the Tunisian diet.

Tunisia is a traditional exporter of durum. In the five years 1960/61-1964/65, exports of durum averaged 64,000 metric tons per year. Average yearly production was 352,000 metric tons during this period. Most of the durum exported goes to France.

Bread wheat (blé tendre)

Bread wheat, Triticum vulgare, is less important, in terms of quantity produced, to Tunisian agriculture than is durum. Between 1959 and 1969, the area seeded to bread wheat averaged 154 thousand hectares of the total 1.0 million devoted to wheat production.

Although Tunisian bread wheat is planted in the fall for growth over the winter, as is durum, it is agronomically more closely akin to the hard white wheat, a spring wheat, grown in the Pacific Northwest of the United States. Winter wheats in the United States require the cold weather shock and period of dormancy in the winter for their growth and maturity in the spring and early summer. The bread wheat grown in Tunisia does not have this requirement.

For the American, used to U.S. market terminology, the name "blé tendre" can be a source of confusion. Literally translated, it means "soft wheat". In comparison with the different U.S. market classes of wheat, "blé tendre" would be considered a hard wheat. Soft wheat in the U.S. is used for pastry and cake flour. Tunisian "blé tendre" has a protein content of about 12.5 percent on a dry matter basis which is somewhat higher than that of the hard white varieties grown in the American Pacific Northwest. Its principal use is for the manufacture of bread flour. The U.S. soft wheats have protein contents which typically range well below that of "blé tendre".

2/E. C. Curwen and G. Hatt, Plough and Pasture, New York, Collier Books, 1961, pp. 20-31.

Tunisia is an importer of bread wheat. In the five years 1960/61-1964/65, imports of "blé tendre" averaged 223,000 metric tons per year. Average yearly production was 79,000 metric tons during this period. Most of the imports have come from the U.S. under PL 480.

WHEAT PRODUCTION: TRENDS AND VARIABILITIES

The statistical estimates in this section were derived from data obtained from the Annuaire Statistique de la Tunisie and from the Office des Céréales. The latter, is a state-owned organization which controls the marketing of wheat in Tunisia. It purchases wheat from farmers at fixed prices established by the Government and sells wheat to flour millers. The Office des Céréales, also has a monopoly on all imports and exports of wheat.

As is true in many developing countries, the reliability of production statistics in Tunisia is open to question. Reported data may not reflect actual production for two reasons that are worthy of mention. First, many small farmers in Tunisia may have little surplus wheat to market after retains for home consumption. Consequently, wheat consumed on the farm where it is grown can be a sizeable amount of total production. Estimates of the amount of wheat produced for home consumption are difficult to make and may result in errors. Second, a significant amount of wheat that is sold by farmers does not enter the official marketing system as operated by the Office des Céréales. Since farmers must pay a tax of about 10 percent of the official price when they sell to the Office des Céréales, they can often obtain a higher net price through the sale of their wheat outside of the official marketing channels. Hence, a "marché toléré" has developed through which a sizeable amount of wheat may move.

Wheat production data issued by the Office des Céréales include estimates of wheat produced for home consumption as well as the "marché toléré", but it is not known how accurate these estimates are. It should be noted that in 1966 a Consumption Survey was conducted over the whole of Tunisia, the results of which lead to rather different estimates of the total consumption of wheat in Tunisia (and hence of production). In the Appendix to this paper, an attempt is made to reconcile wheat production data with aggregate data on wheat consumption as derived from the Consumption Survey. The difference between the statistics of the Office of Céréales and those developed from the Survey is so large, particularly for Durum wheat, that it would seem desirable in the future to examine more closely the statistics on the level and trends of wheat production in Tunisia. However, in the absence of such information the data used in this study are those as reported by the Office of Céréales.

NATIONAL AVERAGES: 1949-1969

Area devoted to wheat in Tunisia expanded greatly between the mid-1930's and the end of the 1950's. As shown in Table 1, the 1934-35 to 1938-39 average area in wheat was 750 thousand hectares. This increased to 1,229 thousand in the period 1954-55 to 1958-59. In the decade of the 1960's, however, wheat area has declined. Agricultural development plans have emphasized agricultural diversification and intensification. This has resulted in the transfer of some of the poorer wheat lands into labor intensive tree crops such as apricots, almonds, and olives as well as into permanent pasture. Nevertheless, wheat will probably continue to occupy an important place in Tunisian agriculture because alternative crops suited to dry land farming are limited.

The statistics analyzed in this section are portrayed graphically in Figures 1-3. Figure 1 shows the surface area planted to each wheat, Figure 2 shows total production and Figure 3 shows average yields.

Figure 1 shows that most of the expansion in wheat area from 1950-1960 was in the area devoted to durum while the area of bread wheat changed little. The expansion in durum area during the period was due to several factors. Among the more important of these were (1) the improved market position of durum relative to that of bread wheat, and (2) improved durum varieties. The decline in wheat area since 1960 also came out of the area devoted to durum. This reduction in durum area is attributable in part to the implementation of the Triennial Plan, 1962-64 and later Quadrennial Plans. These have called for increased emphasis on the production of higher yielding bread wheat and a reduction in the area of durum.

Over the twenty year period 1949-1969, farmers in Tunisia planted an average of 5.1 hectares of durum to every hectare of bread wheat (Table 2). During the last ten years of this period, 1959-1969, the ratio was somewhat higher, 5.5:1. During the last five years, 1965-1969, however, the ratio of durum area to bread wheat area was 4.5:1.

The land area devoted to durum is not only considerably greater than that devoted to bread wheat, but, as shown in Figure 1, durum area also varies more from year to year. This variation may be due to soil moisture conditions at planting time. When soil moisture is not favorable in the fall, less land is likely to be planted to durum with more land planted to other cereals such as barley. Bread wheat is concentrated in the north where such substitutions are less likely.

As shown in Figure 2, production of the two wheats varies substantially from year to year. This is attributable to changes in the area planted as well as to changes in the yield per hectare. The latter is shown in Figure 3. It is evident that yields of both wheats are highly variable and that yields of bread wheat have declined relative to those of durum since 1949.

Table 1. Average areas devoted to wheat and wheat production in Tunisia, averages five year periods, 1934-1969°

Harvest Years	Hectares (1,000 ha)	Production (1,000 m.t.)
1934/35 - 38/39	750	385
1949/50 - 53/54	946	516
1954/55 - 58/59	1,228	504
1959/60 - 63/64	1,117	450
1964/65 - 68/69	862	372

Sources: International Wheat Council, World Wheat Statistics, Haymarket House, Haymarket, London S.W.1, 1969

Office des Céréales

Table 2. Average areas devoted to wheat in Tunisia, 1949 - 1969 and 1959 - 1969.

	Average area 1949-1969	Average area 1959-1969	Average area 1965-1969
	(1,000 ha)		
Durum	874	848	704
Bread wheat	170	154	158
Total	1,044	1,002	862
Ratio of Durum to Bread wheat	5.1:1	5.5:1	4.5:1

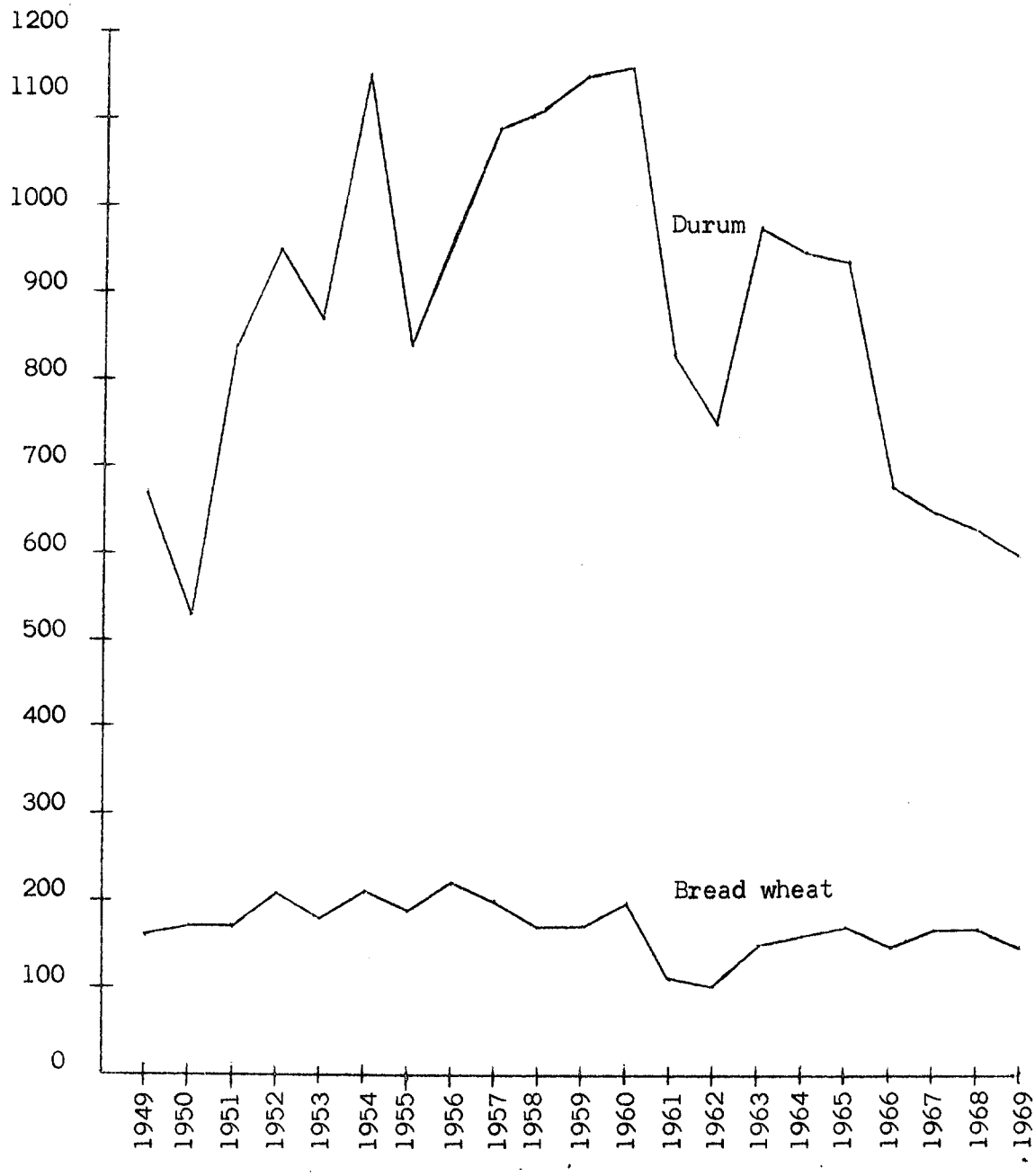


Figure 1.--Tunisia - Areas of bread wheat and durum in 1000 hectares, 1949-1969.

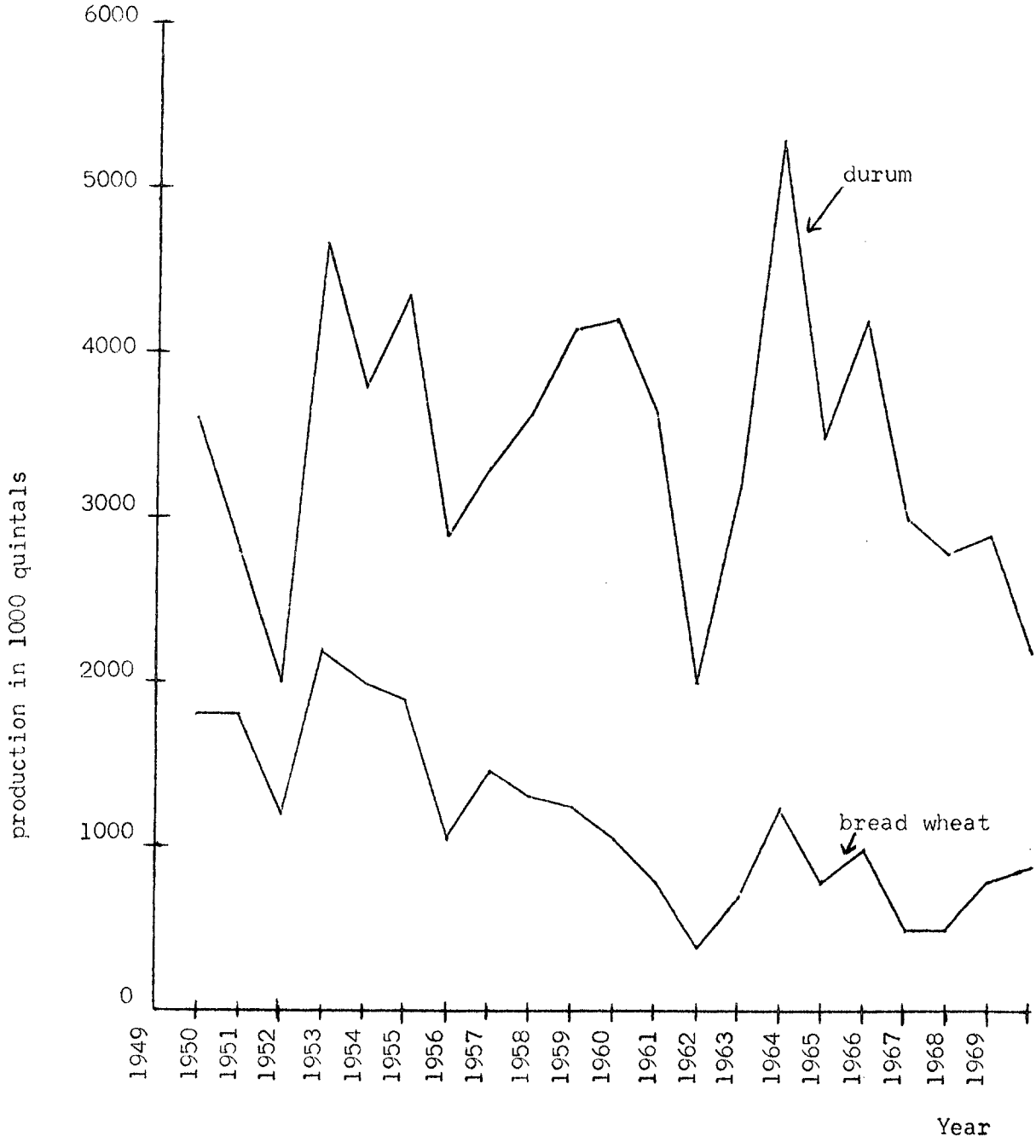


Figure 2 - Tunisia - Production of bread wheat and durum in 1000 quintals* 1949-1969.

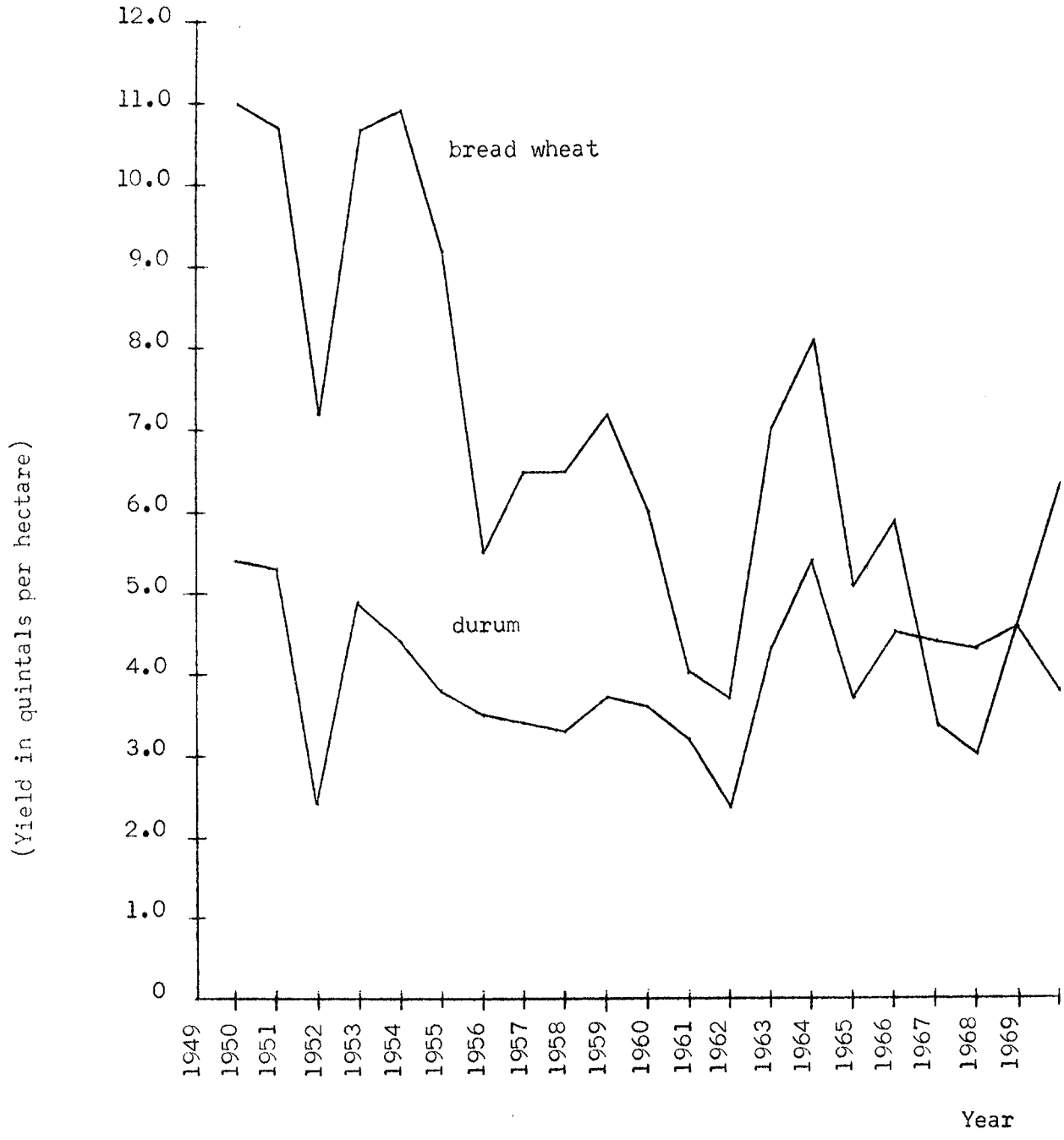


Figure 3 - Tunisia - Average yields in quintals per hectare of bread wheat and durum, 1949-1969.

The statistics in Table 3 measure the extent of the variation in yields. Over the entire twenty year period, 1949-1969, yields of durum averaged 4.0 quintals per hectare. Yields of bread wheat averaged 6.7 quintals per hectare or about two-thirds higher than those of durum. There was no noticeable trend in the yields of durum. During the latter part of the period, 1959-1969, yields averaged the same as for the long-term period, 4.0 quintals per hectare. In contrast, the yields of bread wheat averaged 5.0 quintals per hectare during the latter portion of the period or 1.7 quintals below the long-term average yield.

The yield variability is shown by the two statistics - standard deviation and coefficient of variation. The latter states variation in percentage terms and permits comparison of the variabilities of the yields of the two wheats. The standard deviation shows the range on either side of the mean within which approximately two-thirds of the observations fall. Over the full period, therefore, two-thirds of the observed durum yields fell within the range 3.1 and 4.9 quintals per hectare. Two-thirds of the bread wheat yields fell within the range 4.1 - 9.3 quintals. The yield variation in percentage terms shows that the variation of bread wheat yields is somewhat higher than those of durum.

Regional Averages: 1959-1969

Due to the great geographic differences in agricultural resources, particularly rainfall changes from north to south, it seemed appropriate to analyze the data on a regional basis. Data on wheat area and production by Gouvernorat were reported beginning in 1959. This permitted regional analysis of wheat production for the decade 1959-1968. The country divided into three relatively homogeneous regions for this analysis.

Northern Tunisia:	Gouvernorates of Tunis, Béja, Le Kef, Jendouba, Bizerte, Nabeul.
Central Tunisia:	Gouvernorates of Kasserine, Kairouan, Sousse.
Southern Tunisia:	Gouvernorates of Gabès, Gafsa, Medinine, Sfax.

The geographical boundaries of the Gouvernorates are shown in Figure 4.

It was decided to exclude the southern region from the analysis because it accounts for only a small percentage of the production of both wheats in Tunisia, and will probably become even less significant in wheat production in the future.

Table 3.--Average Yield and Variability in Yield of Wheat in Tunisia, 1949-1969 and 1959-1969

	1949-1969			1959-1969		
	Average yield (Qx/ha)	Std. dev. (Qx/ha)	CV[o] (%)	Average yield (Qx/ha)	Std. dev. (Qx/ha)	CV[o] (%)
Durum	4.0	0.9	22	4.0	0.8	20
Bread Wheat	6.7	2.6[oo]	38[oo]	5.0	1.6	31

o The coefficient of variation is defined as the standard deviation divided by the average. When comparing the variabilities of the yields of the two wheats, the coefficients of variation are more relevant than the standard deviations since the averages around which variabilities are measured are not the same.

oo The standard deviation and the coefficient of variation would have been somewhat lower had they been computed after allowance is made for the downward trend in bread wheat yields.

The area, production, and yield data for the North and the Center are shown graphically in Figures 5 and 6. The picture presented in these figures is very similar to that shown for the country as a whole: extreme variability in wheat production and yields.

Table 4 shows the average areas during the decade 1959-1968 devoted to durum and bread wheat in both regions. The importance of durum is brought out by the ratio of durum to bread wheat. Durum is less important relative to bread wheat in the North than in the Central part of the country. The area devoted to durum has declined over the decade in both regions. The decline in durum area has been greater in the Center due to the conversion of some of the poorer wheat land into tree crops and pasture.

The difference between the productivities of the two regions and the extreme variability in yields is brought out by the statistics in Table 5. The 5.1 quintals per hectare average yield of durum in the North is about 2.5 times the 2.1 quintals yield in the Center. Using the rule-of-thumb, 0.5 quintals per hectare as seed, farms in Central Tunisia received an average of 1.6 quintals of durum to cover other production expenses and net income. Bread wheat yields in the Center are a little better, but the 6.8 quintals average yield in the North is 2.2 times that received in the Center.

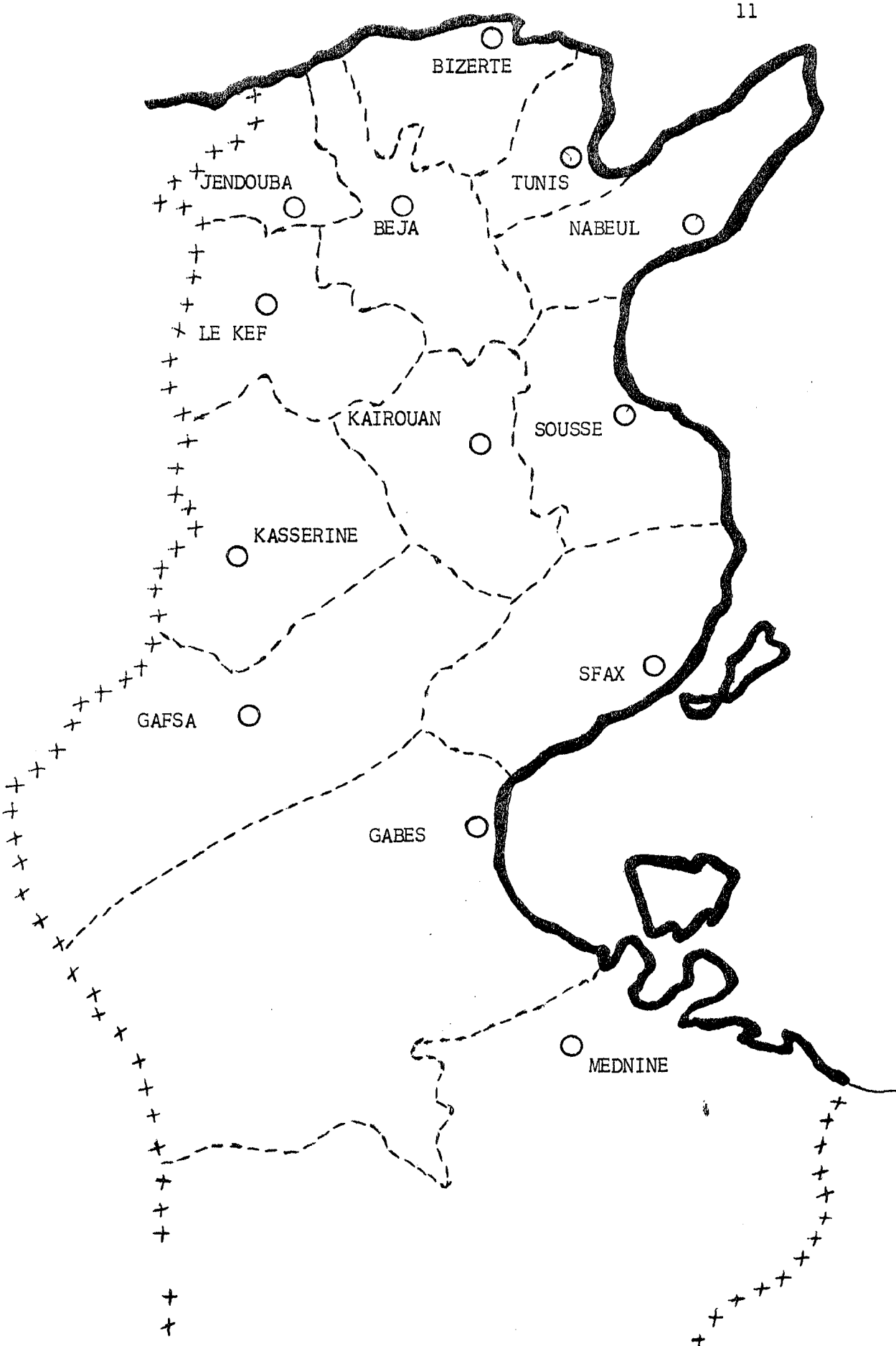
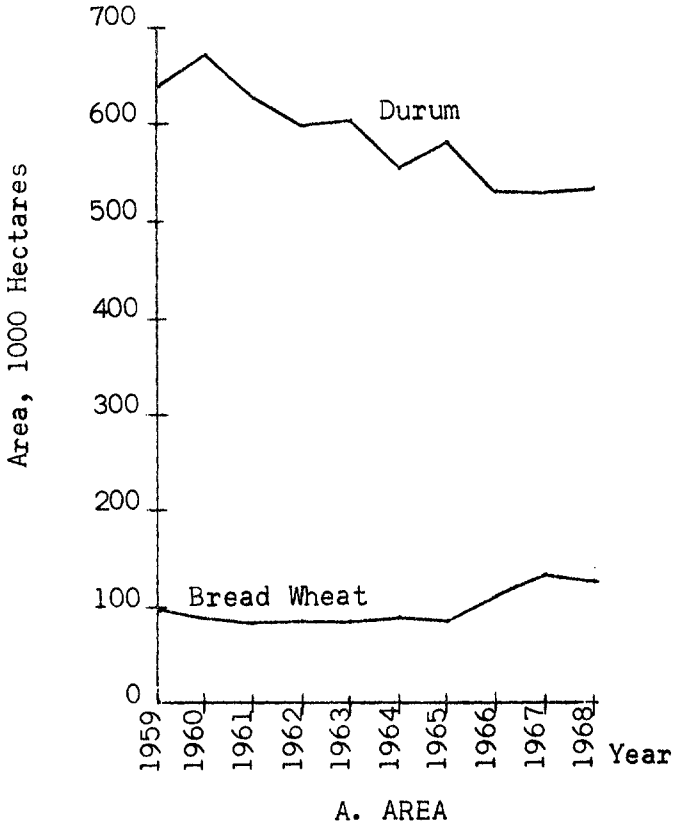
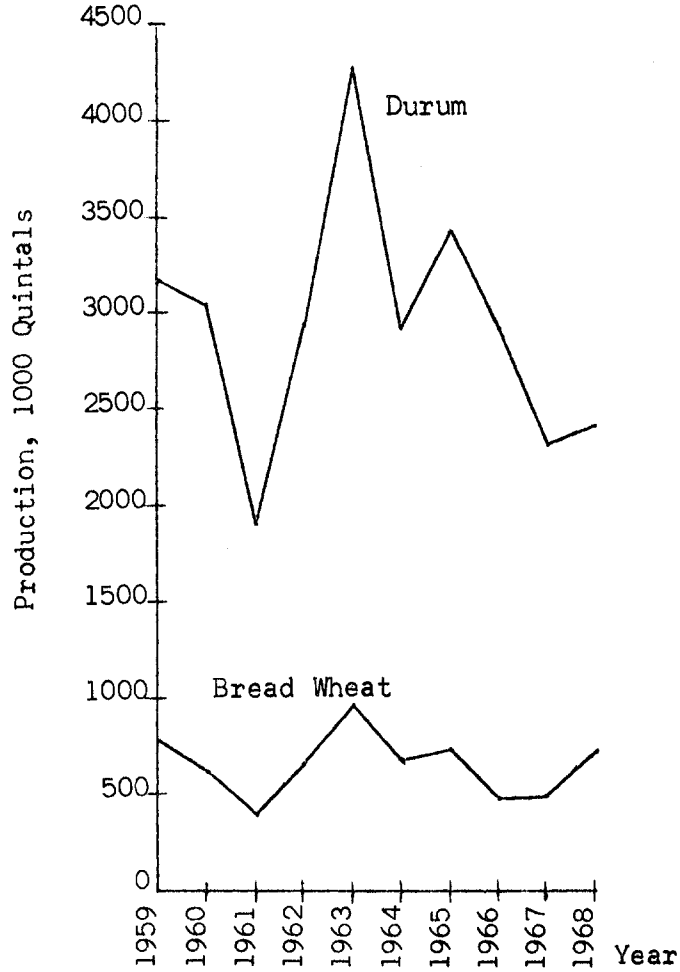


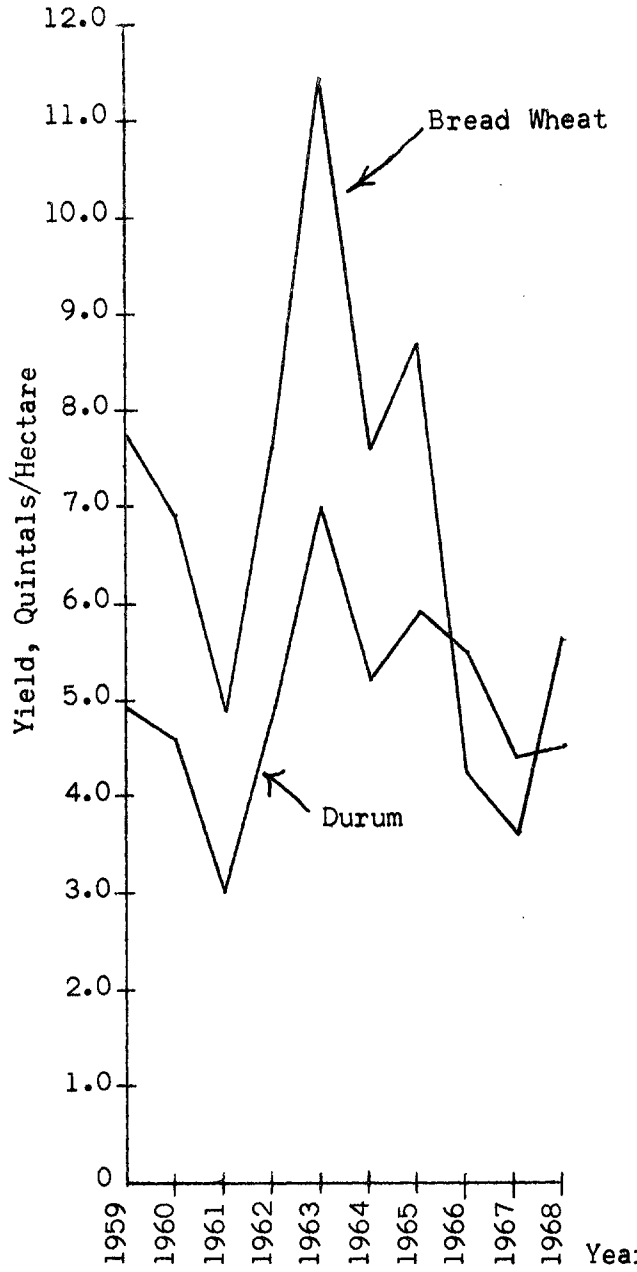
Figure 4 - Map of Tunisia with boundaries of the gouvernorat



A. AREA

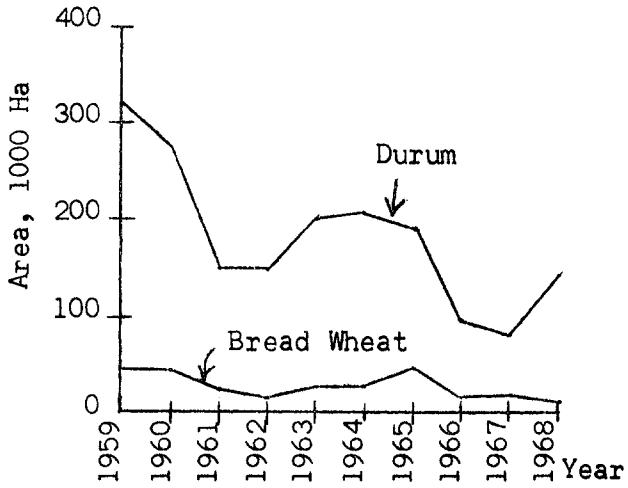


B. Production

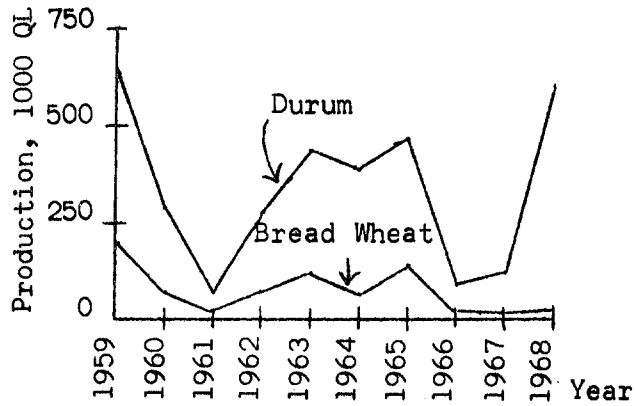


C. Yield

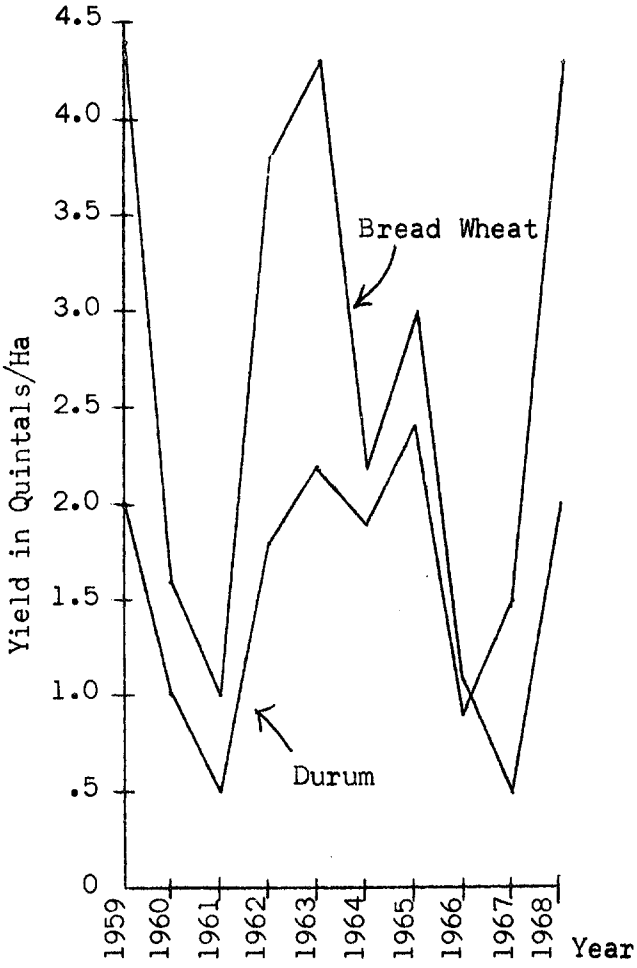
Figure 5: Northern Tunisia (Governments of Beja, Le Kef, Jendouba, Bizerte and Nabeul). Area, Production and Yield of Bread Wheat and Durum, 1959-68.



A. AREA



B. Production



C. Yield

Figure 6: Central Tunisia (Governments of Kasserine, Kairouan, Sousse) Area, Yield and Production of Durum and Bread Wheat, 1959-68.

Table 4 - Average areas devoted to wheat in Northern and in Central Tunisia 1959 - 1968.

Average Areas	North	Central
	(1,000 ha)	
Durum	587	179
Bread wheat	98	27
Total	685	206
Ratio: Durum to Bread Wheat	6.0:1	6.6:1

Table 5. Average Yield and Variability of Yields of Wheat in Northern and Central Tunisia, 1959-1968.

	Northern Tunisia			Central Tunisia		
	Average Yield (Qx/ha)	Std. Dev. (Qx/ha)	CV° (%)	Average Yield (Qx/ha)	Std. Dev. (Qx/ha)	CV° (%)
Durum	5.1	1.1	21	2.1	1.2	58
Bread Wheat	6.8	2.5	36	3.1	2.2	70

° The coefficient of variation is defined as the standard deviation divided by the average. When comparing the variabilities of the yields of the two wheats, the coefficients of variation are more relevant than the standard deviations since the averages around which variabilities are measured are not the same.

The most striking statistics in Table 5 are those which show variability. Again, the Center is the more remarkable region. The variability of yields in the Center are about twice that in the North. The standard deviation of 1.2 quintals per hectare in Central Tunisia for durum indicates that in only four years out of six did the yield lie in the range .9 - 3.3 quintals per hectare. In the other two years, it was outside the range, either above or below. So in one year out of six the farmer at best gets back a little less than twice his seed. In percentage terms, the variability of bread wheat yields is even greater - yield variabilities of 70 percent on either side of the average.

WHEAT PRODUCTION: FURTHER ANALYSIS

There can be no question that wheat yields in Tunisia are highly dependent upon natural conditions of which moisture availability is probably the most important. This is well illustrated in the geographic dimension by the statistics computed for Table 5. In the Center, wheat yields are both lower and are much more variable than they are in the higher-rainfall North.

Some idea of the dependence of wheat yields on rainfall in the time dimension can be obtained through the correlation of yields with periods of wet and dry weather. Mr. Lee Dutcher, former meteorologist for USAID/Tunis, has divided the period 1944-1962 into shorter weather periods which he distinguished as being either wet or dry.[4/] The correlation between the wet-dry variable and wheat yields is shown in Figure 7.

Although the correlation is not perfect, the data in Figure 7 suggest that there is a definite positive relationship between rainfall and average yields. In years of dry weather, durum yields tend to be concentrated below their average. A similar and even more definite relationship is observed in the case of bread wheat. In this case, yields are measured as deviations above and below the 1946-56 and 1957-66 means.

The relationship shown is more exact than might be suspected considering the nature of the data. Wet and dry is a relatively crude index with which to measure weather, and the yield data, being nationwide averages, do not allow for geographic variation from an overall weather pattern.

The relationship between wheat yields and total September-April rainfall has been examined graphically for an individual farm in

---

4/Russel B. Gregg, Agricultural Credit in Tunisia, USAID/Tunis, 1967, p. 9. In this paper, the data were extended up to the present.

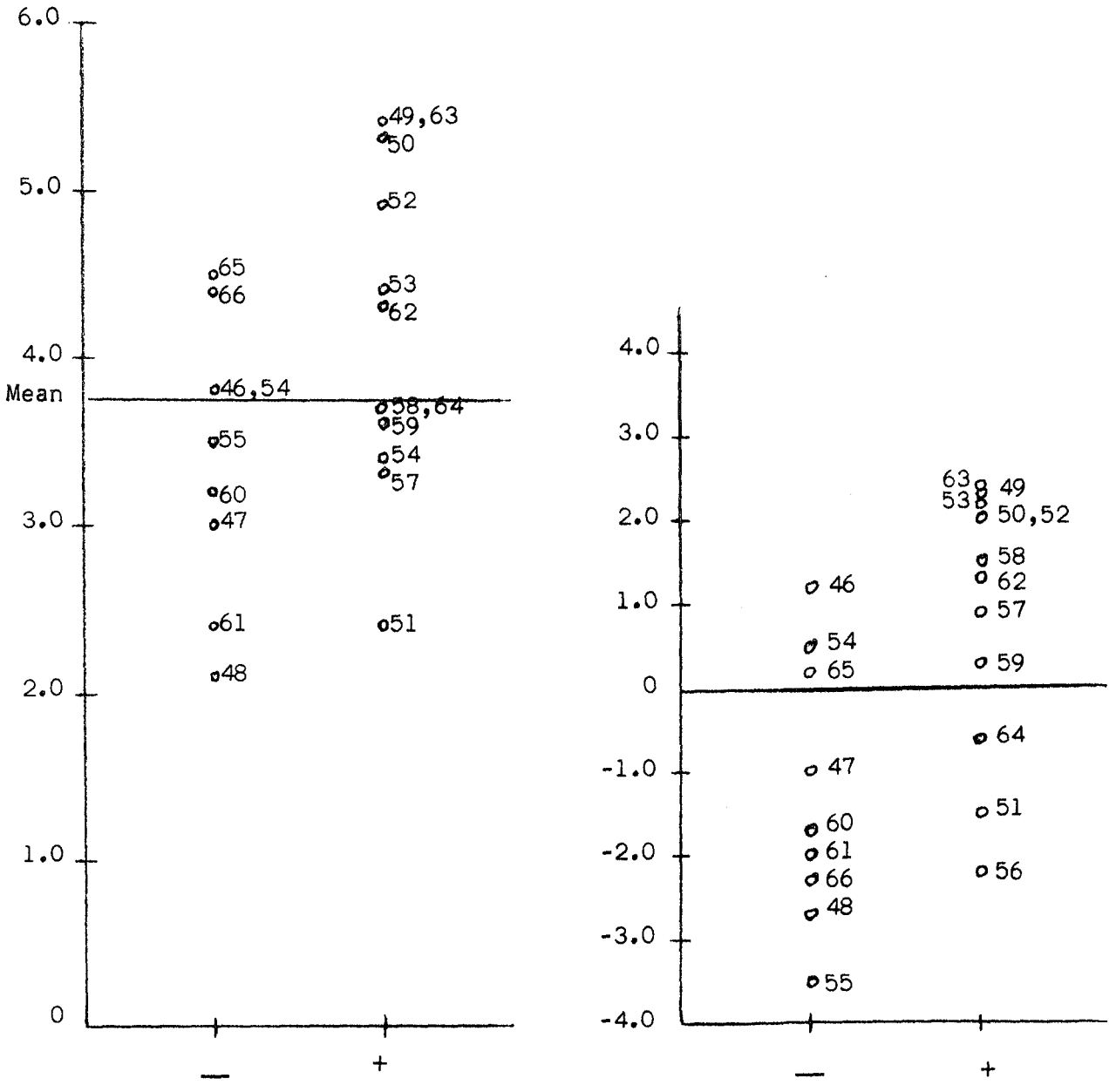


Figure 7. Correlation between national average yields of durum and bread wheat and years of dry (-) and wet (+) weather. The yields of bread wheat are shown as deviations from their mean values of 8.7 qx/ha in 1946-56 and 5.7 qx/ha in 1957-66.

Tunisia.[5] This study showed that the correlation between the two variables was quite close. Important departures from the relationship were associated with highly favorable (or unfavorable) intra-year rainfall distribution and; in one year, a severe frost in April.

The dependence of wheat yields on weather may provide part of the explanation for low wheat yields in Tunisia. The extreme variability of yields relative to unpredictable receipts of necessary moisture make wheat production a risky enterprise. This, in turn, very likely inhibits the employment of expensive production inputs such as fertilizer, which are designed to increase wheat yields.

In addition to the inhibiting effects of nature, the reduction of production resources applied to wheat, associated with the important political events of the 1950's, undoubtedly had an impact on wheat yields. The struggle for independence, beginning in the early 1950's and climaxing in full independence in 1956, created a climate of uncertainty in the minds of the colon farmers. Such uncertainty tended to reduce the investments for maintaining soil fertility and in production resources such as machinery. Since, as shown in Table 6, the colons had produced more of the bread wheat than did the Tunisians, the effect on wheat yields was manifested more strongly in bread wheat than in durum.

Table 6.--Average areas devoted to durum and to bread wheat by Tunisian and European farmers, 1946-1958

	Durum (1000 ha)	Bread wheat (1000 ha)
Tunisian	718	63
European	105	120

Sources: Annuaire Statistique de la Tunisia, Statistique Générale de la Tunisie, Tableaux Statistiques (Annexes of Report au Président de la République sur la situation en Tunisie).

5/"Pluviometrie et Stabilité de la Production", Terre de Tunisie, Bulletin du Secrétariat d'Etat a l'Agriculture, No. 4, Janvier, 1958, pp. 59-63.

The question of why most of the bread wheat was produced by European farmers while most of the area devoted to durum was farmed by Tunisians is outside the scope of this paper. This question will be examined in a later study as a part of an analysis of price policy for wheat in Tunisia. The likelihood that many small Tunisian farmers produce primarily for home consumption may be important. Durum, therefore, is preferred because of the traditional importance of semolina products such as couscous in their diets.

Another causative factor in the long-term decline of bread wheat yields was the change in crop rotations over time. Previous to World War II, most wheat in Tunisia was grown in a two-year rotation of wheat and fallow. Rotations were subsequently changed gradually in the North of Tunisia to a three-year rotation in which bread wheat followed durum. Since bread wheat did not then benefit from fallow in the previous year, its yield performance declined.

Since 1962 the agricultural plans of the Tunisian Government have called for further changes in crop rotations. These recommend the inclusion of forages and edible legumes along with wheat and further reduction in fallow wherever moisture is adequate. Bread wheat, however, still follows durum in these rotations and does not receive as much benefit from the forage or legume crop as does durum.

MEXICAN WHEATS IN TUNISIA

The Government of Tunisia in cooperation with USAID is now attempting to increase the production of bread wheat through the introduction of Mexican semi-dwarf varieties. Higher yielding wheat varieties could make a substantial contribution to agricultural income in Tunisia because of the importance of wheat in the farm economy.

Mexico has achieved considerable success in increasing its wheat production with new varieties developed with the assistance of the Rockefeller Foundation. Wheat yields in Mexico increased from an average of 6.5 Qx per hectare in 1943 to 28.4 Qx per hectare in 1965.

New wheat varieties developed in Mexico have been found to be relatively insensitive to differences in the length of the day and light intensity. Consequently, they are adaptable to other countries of the world. India, Pakistan, and Turkey, for example, have purchased substantial quantities of Mexican wheat seed in recent years. India purchased 265 metric tons of Mexican wheat seed in 1966 and 18,000 tons in 1967. Pakistan started with 350 tons in 1966 and boosted it to 42,000 tons in 1967. Turkey bought 60 tons in 1966 and increased it to 22,000 tons in 1967.

Most of the experience with these new wheat varieties in Mexico, India, and Pakistan has been on irrigated land. In Mexico for example, 86 percent of the market value of wheat in 1961 came from land under

public irrigation. Nevertheless, these same wheats have produced well under dry-land farming in the higher rainfall areas of Turkey.

Wheat in Tunisia is currently produced under dry-land farming. Since the amount of irrigated land in Tunisia is limited, indications are that most of the wheat in the future will also have to be grown under dry-land conditions. Mexican wheat varieties may have considerable potential in areas well adapted to wheat in Tunisia. Since these wheats have a shorter growing season than native varieties, they can be planted later and harvested earlier. Consequently, their growing season can be more readily geared to the period when most of the rainfall is received.

Tunisia currently has a sizeable deficit in its consumption requirements of bread wheat. Accordingly, it must use scarce foreign exchange to finance bread wheat imports. This drain on foreign exchange will become more intense unless the trend in the declining yields of bread wheat is reversed because consumption can be expected to rise over time with increases in population and consumer incomes.

What are the possible implications of new high yielding wheat varieties to land resources use in Tunisia? During the five crop years 1960-61 and 1964-65, an average of 145,200 hectares were planted to bread wheat each year. Average yearly production of bread wheat was 79,400 metric tons or 5.5 Qx per hectare. Average yearly consumption during this period, however, was 305,000 metric tons with the excess of consumption over production made up through imports.

Agronomists estimate that under proper management Mexican short-straw wheats might yield an average of 20 Qx or more per hectare. While a national average yield of this magnitude might be optimistic, had Tunisia been able to achieve this yield on 145,000 hectares devoted to bread wheat, average production would have been 290,000 metric tons, which was near its self-sufficiency in bread wheat. Consequently, it may be possible to achieve self-sufficiency in bread wheat with a relatively small shift of wheat acreage from durum to bread wheat. But it should be noted that with increases in population and per capita income, consumption of bread wheat will also rise. This would necessitate a shift in acreage from durum to bread wheat to maintain the level of self-sufficiency in bread wheat.

SUMMARY AND CONCLUSIONS

Analysis of time series data in this paper has demonstrated that wheat yields in Tunisia are extremely variable from year to year. The average yields of bread wheat have also declined since 1949 while yields of durum displayed no discernable trend either up or down.

Average yields of both durum and bread wheat are approximately 2.5 times greater in Northern Tunisia than in the Central region. The variability in yields in the latter region is about twice that in the former. In one year out of six, the farmer producing durum in Central Tunisia will at best just get back twice his seed from the crop.

The average yield of bread wheat in all of Tunisia for the period 1949-1969 was two-thirds higher than that of durum. During the latter portion of the period, 1959-1968, regional data showed that average bread wheat yields exceeded those of durum in both Northern and Central Tunisia. Nevertheless, more than five times as much land resources have been devoted to durum as to bread wheat.

The successful introduction of Mexican short-straw wheats in Tunisia could substantially increase the production of bread wheat. It may be possible for Tunisia to achieve self-sufficiency in bread wheat with a relatively small shift in hectarage from durum to bread wheat if agronomists estimates of the yield potential of these new wheats materialize.

A major implication of the analysis in this paper is that the same environmental factors that cause wheat production to vary substantially from year to year and prevent farmers from achieving yield potentials inherent in existing varieties will also represent limitations on new wheat varieties. But, the influence of environmental factors and the resulting production risks should be lowered with the new Mexican varieties since their growing season is shorter. However, as is true with most applications of science and technology to agriculture, the economic risks associated with the new wheats are greater since higher production input costs are required in the form of land and seedbed preparation, fertilizers, and possible herbicides. Consequently, a crop failure can be costly. This makes proper management of utmost importance if the impact of environmental factors over which lesser control can be exercised, is to be minimized.

APPENDIX

LIMITATIONS OF WHEAT PRODUCTION DATA

The preceding analysis was based on the "official" wheat production data as published in the Annuaire Statistique de la Tunisie and issued by the Office des Céréales. As was pointed out earlier in this paper, these data may be subject to sizeable errors because of difficulties in making accurate estimates of the amount of wheat produced for home consumption and in accounting for wheat that moves through the "marché toléré", or outside of the official marketing system as operated by the state-owned Office des Céréales.

A household food consumption survey covering all of Tunisia was made for the year 1966. It is of interest to compare the total consumption of bread wheat and durum as indicated by this survey with total consumption of the two wheats as derived from supply and distribution tables. This may indicate possible errors in the wheat production data.

As shown in Table A-1, the total consumption of bread wheat and durum in 1966, as derived from this survey, was 200 thousand and 403 thousand metric tons, respectively. Total consumption in the same year as estimated from supply and distribution tables, (Table A-1) was 255 thousand metric tons for bread wheat and 262 thousand metric tons for durum. With the latter method, total consumption is a residual figure after accounting for production, changes in stocks, imports and exports. Consequently, bread wheat consumption was 55 thousand metric tons more as derived from supply and distribution tables, while durum consumption was 141 thousand metric tons less.

These differences can result from a number of factors the more important of which would be (1) methods used to convert the consumption of cereals products (bread, flour, cous-cous, etc.) as derived from the consumption survey back into cereals, and (2) the accuracy of production and stocks data in the supply and distribution tables.

In the case of bread wheat, it seems reasonable to place more reliance in the higher consumption figure as derived from the supply and distribution tables for the following reasons: (1) A substantial share of the bread wheat supply comes from imports and these data are subject to less error, (2) Bread wheat production is concentrated on larger farms in the north with relatively small amounts produced for home consumption and larger amounts move through official marketing channels. Hence, production estimates of bread wheat are probably more accurate than for durum. We can conclude, consequently, that the official production data on bread wheat production as used in this paper are probably subject to less error. At least, it is more difficult to argue that the official production data on bread wheat are lower than actual production. When allowance is made for possible errors in converting consumption of bread wheat products back into bread wheat, the consumption survey agrees quite well with the supply and distribution tables.

In the case of durum, consumption derived from the supply and distribution tables was 141 thousand metric tons less than that derived from the consumption survey. This is more than 50 percent greater than the total consumption of durum as derived from the supply and distribution tables for the year 1966. For purpose of comparison only, the production of bread and durum wheats for 1965 as derived from the data of the Office of Céréales and from an interpretation of the Consumption Survey are as follows (See tables A-2 and A-3).

Production Estimates on the basis of:

	Office of Céréales	Consumption survey	Interpretation as above of (1) & (2)
	(1) (1000 tons)	(2) (1000 tons)	(3) (1000 tons)
Bread wheat	100	45	100
Durum wheat	420	561	561
All wheat	520	606	661

Table A-1.- Estimates of Aggregate Consumption: Durum and Bread Wheat, 1966.

Cereal	Consumption Survey[1] Per capita (Kilograms)	Consumption Survey[1] Total[2] (1000 tons)	Total consumption from supply and distribution tables (1000 tons)	Difference (1000 tons)
Bread Wheat	44	200	255	+ 55
Durum	89	403	262	-141

1) La Consommation et les Depenses de Menages en Tunisie, 1965-1968, République Tunisienne, SEPEN, Direction Générale du Plan, Décembre 1968. Tableau 54, p.160.

2) Per capita consumption multiplied by 1966 population of 4,533 thousand persons from census.

Table A-2.-Bread Wheat and Durm: Estimated Supply and Distribution 1965-66 and 1966-67

Consumption Year	Bread Wheat 1965-66	Bread Wheat 1966-67	Durum 1965-66	Durum 1966-67
	(1000 metric tons)			
Supply				
Stocks, July 1	37.0	14.5	50.0	35.0
Production	100.0	49.0	420.0	300.0
Imports	152.4	263.6	0	0
Total Supply	289.4	327.1	470.0	335.0
Distribution				
Consumption	255.1	282.1	262.0	254.8
Exports	2.0	0.5	101.0	4.2
Seeds and losses	17.8	18.0	72.0	68.5
Ending Stocks	14.5	26.5	35.0	7.5
Total Distribution	289.4	327.1	470.0	335.0

Source: Office des Céréales

Table A-3.-Bread Wheat and Durum: Supply and Distribution 1965/6 on the basis of Consumption Survey

	Bread Wheat	Durum
	(1,000 metric tons)	
Supply		
Stocks (1st July) 2)	37.0	50.0
Production 3)	44.9	561.0
Imports 2)	152.4	0
Total Supply	234.3	611.0
Distribution		
Consumption 1)	200.0	403.0
Exports 2)	2.0	101.0
Seeds and losses 2)	17.8	72.0
Ending stocks 2)	14.5	35.0
Total Distribution	234.3	611.0

1) On the basis of Consumption Survey, see table 7

2) Office of Cereals - same as Table 8

3) Production obtained by difference i.e. quantity necessary to balance supply and distribution. (1968 production.)