THE ARAB CENTER FOR THE
STUDIES OF ARID ZONES AND DRY LANDS (ACSAD)

ECONOMIC AND ANALYTICAL STUDY OF WHEAT AND BARLEY PRODUCTION IN ALGERIA

Damascus, May 1986

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CONTENTS

Foreword

The work plan of the ACSAD -IFAD Cereal Development Project included, inter alia, the carrying out of analytical studies for the economics of the production of wheat and barley in the Project participating countries, namely Morocco, Algeria , Jordan and Syria with the aim to determine the capabilities of these countries and find ways to improve their production qualitatively and quantitatively .

After collecting the available data and diagrams the Project administration and the ACSAD section of statistics have prepared this analytical study for Algeria . The study has been carried out by the following experts :

- Dr. Farid Al-Malki,	Head of the Section of Statistics , ACSAD .
- Dr. Khaled Al-Najjar,	Head of the Section of Agroeconomy, Faculty of Agriculture, University of Aleppo .
- Dr. Mohamed Zafer Muhabbak,	Vice-Dean of Faculty of Economy, University of Aleppo .

ACSAD and the Project Administration wish to thank these experts and everyone participated in the preparation and production of the study .

Dr. Mohamed EL-KHASH
Director General
ACSAD

INTRODUCTION:

In spite of the relative development which took place in various national economic sectors in Algeria through the implementation of the economic and social development plans as from 1967 it appears that local food products has failed to keep pace with increased demands for these products . This situation could be due to some major causes such as the growth of population at high rates (3.23% p.a.) and the rise of the average per capita income of the Gross Domestic Product which reached 3.2% p.a. noting that agricultural production grew at a rate of 2.3% p.a.(1) This situation has created a big food gap and this in turn caused a decrease in the per capita share of local food products and led to the increase of imported food products wich amounted to some US$ 1816.09 million 47.5% of which were related to cereals (57.2% for wheat and barley) .

The above data indicate that Algeria is facing nowadays a real challenge which may affect its food security . Therefore, it is of maximum importance to concentrate all efforts with the aim to limit the food gap . In order to bridge the food gap it is necessary to take all measures that would provide opportunities for increasing local production of agricultural products in general and food products in particular . This could be achieved through the horizontal or

(1) Arab Organization for Agricultural Development, Annual Book for Agricultural Statistics, Volume 4, Khartoum, 1984, P. 51 and 422 .

- Arab Organization for Agricultural Development, Arab Agricultural Policies, 5th Part, Khartoum, 1983, P. 7 .

vertical intensification of crop production .

Exports of oil and oil products provide Algeria with momentum to exploit all available human and agricultural resources and maintain high growth rates in agricultural production . Algeria should take quick action with the objective of bridging the food gap and acheiving the food security which constitutes one of the main strategies in the question of regional and national security . Specialized studies and research are important aspects for agricultural development because solutions for agricultural problems could be offered through these studies and research . This study will deal mainly with one aspect of the food gap in Algeria, i.e. wheat and barley . The study includes 4 major parts :

Part 1:

It includes an analytical review of the main features of agricultural sector . This review deals with the status of agriculture in the national economy and its role in achieving food security . It also deals with the present situation of agricultural resources, production inputs, crop structure and management of agricultural holdings .

Part 2:

It includes an analytical study of the development of wheat and barley (area, production and productivity) . It highlights the deviations and problems facing these two crops and the possible solutions .

Part 3:

It includes an analytical study of rainfall, rain fluctuation and rainfall cycle noting that rainfall is an important factor affecting rainfed agriculture which dominates most of wheat and barley areas .

Part 4:

It includes a study of the main factors affecting production of wheat and barley .

Part 1:

1. Main Features of Agricultural Sector:

Algeria is rich in various economic resources such as oil , gas and different metals . The country is also rich in agricultural resources . The combination of economic resources and agricultural resources provides Algeria with potentials and capabilities that allow the country to launch an overall economic and social development provided that these resources are utilized in an optimum way .

The economic importance of the Algerian agricultural sector along with its main features can be highlighted through the following :

1.1 Agricultural Status in the National Economy:

1.1.1 The Relative Importance of the Agricultural Sector in the National Economy:

The developing countries are characterized by the dominance of agricultural sector over other sectors in the national economy . Some developing countries deviate from this feature where one can find that non agricultural economic sectors are dominant . The latter situation applies on the Algerian national economy where the industrial sector is dominant . Table 1 shows the relative importance of some sectors in gross domestic product .

Table 1 shows that the gross domestic product increased during

TABLE 1: DEVELOPMENT OF THE GROSS DOMESTIC PRODUCT BY SOME ECONOMIC ACTIVITIES (1000,000 DINARS AT 1974 PRICES)

Year / Activity	1969		1970		1975		1979		1980	
Agriculture	2986.7	7.7%	3219.9	7.6%	4254.9	7.8%	4130.7	5.4%	4425.8	5.6%
Industry	21037.8	54.4%	23028.9	54.3%	30089.8	55.5%	45134.2	59.5%	44650.9	57.1%
Services	8280.1	21.4%	9066.1	21.4%	1084.5	20%	16127.9	21.3%	17593.1	22.5%
Total of added value	32304.6	--	35314.9	--	45189.7	--	65392.8	--	66569.8	--
GDP	38635.3	100	42388.7	100	54230.5	100	75764.3	100	78142.3	100

Source: Collected and calculated from data available in Arab Agricultural Policies, previous reference, P. 6.

1969-1980 from 38635.3 million Algerian Dinars in 1969 to 78142.3 million Algerian Dinars in 1980 . Various economic sectors contributed to this increase (6.6% for agriculture, 56.7 for industry and 21.4 for services). Table (1) shows also that while there was an increase in the relative importance of income generated from the industrial sector there was a decline in the relative importance of income generated from agricultural sector . This phenomenon is an evidence of the marginal effect of the agricultural sector and the great obstacles which impede its development . A comparison of the income generated from different economic sectors in 1980 and 1969 shows an increase of 212% in the services sector and 148% in the agricultural sector .

We conclude that there is a great need to improve the agricultural sector in Algeria which is associated directly with the question of food security and which plays an important role in the development of the national economy .

1.1.2 Investment Expenditure in Agricultural Sector:

Investment in agricultural sector in Algeria in the development plans was far below the level required to be attained by agriculture in the national economy . The data (1) indicate a decline in the rate of the investment allocations for agricultural sector compared with the total national investment allocations . The rate of investment in the agricultural sector was 26% of the total national investments during the 3 year plan . It decreased to 14% during the 1st 4 year plan (1970-1974) and to 11% during the 2nd 4 year plan (1974-1977) and reached 5.7% during the 5 year plan .

The above indicators show that there was a lack of concentration on the agricultural sector in economic planning process . They show also that all development efforts were concentrated on other sectors, particularly the industrial sector . This situation led to a decrease in the agricultural productivity and this in turn resulted in a continuous deficit in the agricultural balance of trade and the aggravation of the food dependency .

1.2 Indicators of Food Security:

1.2.1 The Relative Importance of Exports and Imports in Foreign Trade:

It is known that foreign trade is the most important aspect

(1) National Bureau for Statistics, Internal Migration, Algeria, 1984, P. 21 .

of the national economy in every country . Total exports and imports reflect clearly the status of foreign trade and indicate whether the general economic foundation is strong or weak .

The importance of foreign trade (exports + imports) in agricultural commodities compared to other commodities is due to the vital role played by agricultural commodities in general and food commodities in particular in the question of food security .

The general economy of Algeria is characterized by its strong connection with the foreign trade, especially with the agricultural commodities . Table (2) shows the relative importance of the agricultural exports and imports in the foreign trade .

Table (2) shows that the value of the total imports exceeded that of the total exports during 1971 and 1975 . Thus a marked deficit occured in the balance of trade in these years while there was a surplus in the balance of trade in 1982 due to oil exports . Regarding agricultural exports in foreign trade it appears that the value of agricultural exports increased markedly in 1975 compared to 1971 but it decreased in 1982 to a level lower than that of 1971 . This is probably due to increased demand for agricultural commodities in general and food commodities in particular as a result of the rise in the number of population, the improvement of the per capita income and the slow-down of growth rates in agricultural production .

TABLE 2: RELATIVE IMPORTANCE OF AGRICULTURAL IMPORTS AND EXPORTS IN FOREIGN TRADE IN ALGERIA (IN MILLION DOLLARS)

Indicator / Year	Total Exports	Total Imports	Agricultural Exports	Agricultural Imports	Agri. Exports to total Exp. %	Agri. Exports to total Imp. %	Agri. Exp. to agric. Imports %	Agri. Imports to total Imp. %
1971	858	1229.28	66.27	641.04	7.72	5.39	10.34	52.15
1975	4297.67	6001.58	209.15	3284.61	4.87	3.48	6.37	54.73
1982	11481.64	10743.53	33.34	2612.38	0.29	0.31	1.28	24.31

Source:

- Arab Organization for Agricultural Development, Book of Analytical Statistics, Ist issue, 1984, P. 144 and 145 .
- Arab Organization for Agricultural Development, Year Book for Agricultural Statistics, Volume 4, 1984, P. 392 .

The agricultural imports experienced an upward trend which reached its climax in 1975 . The value of the agricultural imports constituted a great percentage of the value of the total imports where it amounted to 52.15% in 1971, 54.73% in 1975 and 24.31% in 1982 . In spite of the decline in the percentage of the value of agricultural imports in 1982 compared to the previous periods the value of agricultural imports remained high (US$ 2612.38 million) .

Table (2) shows some important indicators of the situation of agricultural exports and imports .

- A relative decline in the value of agricultural exports of the total exports in a downward trend during the study periods .

- A relative decline in the coverage of the value of total imports from agricultural exports in a downward trend .

- A relative decline in the coverage of the value of agricultural imports from the value of agricultural exports .

These indicators show that the agricultural activity has lost its absolute and relative importance in the contribution to foreign trade . The figures and percentages indicate that the value of agricultural imports are covered from the value of exports of other economic sectors as the case in 1982 when there was a surplus in the balance of trade or when the value of agricultural imports increased the deficit

in the balance of trade as the case in 1971 and 1975 . Finally, we can draw a conclusion that agricultural development in Algeria did not make good progress and it failed to keep pace with the development experienced by other economic sectors, notably the industrial sector .

1.2.2 Food Balance of Trade:

Algeria depends greatly on the outside world to provide food commodities for its population . The figures show a decline in the value of exports and a rise in the value of imports of food commodities and this place the food balance of trade in a continuous deficit . Table (3) shows the development of the value of food exports and imports . Table (3) shows that the value of food exports followed a downward trend during 1970 - 1983 while the value of food imports followed an upward trend during the same period and this situation maintained the deficit in the food balance of trade with the exception of 1970 . The average deficit in the food balance of trade during 1970 - 1979 amounted to AD 2264 million . It increased to AD 8211 million during 1980-1983 . The negative figures in the food balance of trade during the study period reflects the extent of dependency by Algerian economy on the foreign trade in order to secure the food commodities . It also refelcts the inability of the productivity of agricultural sector to meet the local demand for food products . The average growth of the food imports by 6% p.a., the slow growth of agricultural production by 2% p.a. and the population growth at an average of 3.2% p.a. all these indicators make the situation of the Algerian economy unsatisfactory noting that other non agricultural sectors are making good progress .

TABLE 3: DEVELOPMENT OF THE VALUE OF FOOD EXPORTS AND IMPORTS DURING 1970-1983 (IN MILLION ALGERIAN DINARS)

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Food Exports	985	521	536	910	664	687	627	551	534	431	496	519	324	178
Food Imports	626	885	1076	1208	2760	4437	3489	4398	5033	5081	8008	8399	8745	9209
Food Balance of Trade	+359	-364	-540	-298	-2196	-3750	-2862	-3847	-4499	-4650	-7512	-7880	-8421	-9031

Source:

- Arab Agricultural Policies, P. 15 and 232 for data regarding 1980 and before 1980 .

- Ministry of Planning and Construction, Bulletin of Algeria in Figures, 1984, P. 18 for data after 1980 .

We also come to another conclusion that the Algerian food economy is dependent on foreign countries in a way that cause great concern . It was estimated that every 2 of 3 calories [1] consumed in Algeria were imported from other countries (1981) . Undoubtedly, this situation is a great disadvantage to the Algerian economy . Therefore, it is of maximum importance to limit the food dependency which is considered as one of the strategic weapons in the modern history .

In order to get rid of the food dependency it is necessary to improve the agricultural sector and intensify food crops in particular and agricultural crops in general in the framework of a planned agricultural development .

1.2.3 The Relative Importance of the Food Imports:

The food imports have a big share in the agricultural imports. This means that an important part of the allocations for agricultural imports is directed towards direct consumption . This situation deplete the available capabilities to import inputs necessary for agricultural development in particular and social and economic development in general .

Table (4) shows that percentage of the value of food imports to the total value of agricultural imports increased from 28.1% in 1971 to 34.2% in 1975 and to 73.78% in 1982 . Table (4) shows also that the percentage of the value of cereal imports to the

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(1) National Bureau for Statistics, Internal Migration, Algeria 1984, P. 10 .

TABLE 4: THE RELATIVE IMPORTANCE OF THE VALUE OF FOOD IMPORTS AND THEIR COMPONENTS (IN MILLION US$)

Indicator Year	Agricultural Imports	Food Imports	Cereal Imports	Wheat Imp.	Food Imp. to Agri. Imp. (%)	Cereal Imp. to Food Imp. (%)	Wheat Imp. to Food Imp. (%)	Wheat Imp. to Cereal Imp. (%)
1971	641.04	180.13	58.00	52.10	28.1	32.2	28.92	89.82
1975	3284.61	1123.75	407.95	314.51	34.2	36.3	28.00	77.10
1982	2612.38	1927.48	862.13	408.83	73.78	44.73	21.21	47.42

Source:

From data available in :

- Statistical Analytical Book, P. 149 .
- Arab Agricultural Policies, P. 179 .
- Year Book for Agricultural Statistics, P. 422 .

value of food imports increased from 32.2% in 1971 to 36.3% in 1975 and to 44.73% in 1982 .

Wheat is considered as one of the main components of the food imports . The percentage of wheat imports to food imports was 28.92% in 1971 . It dropped to 28% in 1975 and to 21.21% in 1982 . The decline in the relative importance of the value of wheat imports during the study period was mainly due to the increase in the wheat flour imports . Flour imports in Algeria amounted to 750 thousand tons in 1981 and 932.32 thousand tons in 1982 .

Finally, it should be noted that wheat imports constituted most of the cereal imports . The percentage of the value of wheat imports to cereal imports was 89.82% in 1971 . It dropped to 77.1% in 1975 and to 47.42% in 1982 . Now again the decline in the relative importance of wheat is attributed to the increase of wheat flour imports .

Regarding the value of barley imports data indicate that it increased from US$ 51 million during 1979-1981 to US$ 84.42 million in 1982 . It constituted 4.4% of the value of food imports and 9.8% of the value of cereal imports (1982) .

1.3 Agricultural Resources and Production Inputs:

1.3.1 Agricultural Land Resources:

The area of Algeria is 238.174 million hectares[1] of which

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1) According to 1982 census .

7.5081 million hectares are cultivable, i.e. about 3.15 of the total area of Algeria . The cultivable area is used as follows :

- 3.5491 million hectares for rainfed cultivation, i.e. about 47.3% of the total cultivable area .

- 0.324 million hectares for irrigated cultivation, i.e. about 4.3% of the total cultivable area .

- 3.6176 million hectares are left fallow, i.e. about 48.4% of the total cultivable area .

The area of fallow lands fluctuates from year to another according to the trends of the agricultural seasons .

The area of rangelands is about 31.5984 million hectares, and the area of forests is 4.384 million hectares, i.e. about 13.3% and 1.8% of the total area of Algeria respectively (1982). The desert covers about 83% of the total area of the country .

1.3.2 Water Resources:

Water resources in Algeria include rainfall, groundwater and surface water :

Rainfall:

Rainfall occurs in Algeria from September through June . Rainfall averages differ from one area to another . Algeria can be divided into the following areas :

- The coastal area : It receives about 700 mm. of rainfall annually . This area covers the whole Algerian coast with a width of 80-160 km .

- The area of plains : It receives 500-700 mm.

- The area of plateaux : It receives 300-500mm.

- The area of steppes: It receives 100-150 mm .

- The area of desert: It receives less than 100 mm. of annual rainfall .

The amount of rainfall is estimated at about 65 billion[1] m^3 p.a. . Other estimates refer to about 100 billion m^3 p.a. .

Groundwater:

Groundwater is considered as one of the most important water resources needed for agricultural, industrial and human utilization . There are huge groundwater bodies in Algeria the most of which are in Sidi Belabbas and Al-Matyjah plain . The water capacity exploited from groundwater is estimated at about 1.7 billion m^3 .The potentials of the available groundwater are much higher and therefore efforts are being made to increase the amout of water capacity exploited from these resources .

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(1) Arab Agricultural Policies , P. 63-65

Surface Water:

Surface water includes rivers, wadies and dams . The average annual yield of the river Al-Shalf amounts to 60 million m^3 while that of the river Mina amounts to 70 million m^3 .

There is a number of wadies scattered throughout Algeria . Water resources for these wadies come from springs and rains . Al-Abyad is the most important wadi with an average yield of 200-800 m^3 per second , wadi Fussah with 80 km^3 per year and wadi Al-Hamam with 100 million m^3 per year . There are many dams in Algeria . The total storage capacity of these dams is estimated at about 1025 million m^3 which are used to irrigated 32.4 thousand hectares of agricultural lands and this means that great irrigation potentials behind the dams are not used as required due to insufficient irrigation networks .

1.3.3 Human Resources :

The total population of Algeria in 1982 was estimated at about 20.226 million of which 9.552 million live in rural areas, i.e. about 47.22% of the population .

It is important to note that the percentage of people who are within(1) the labour age is 46% of the total population while that of those who are outside(2) the labour age is 54% .

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(1) Including people aged 15-60 years .

(2) Including people aged less than 15 years and more than 60 years .

The Algerian total labour force amounts to 3.422 million, i.e. about 17% of the total population. 960 thousand are in the agricultural labour force, i.e. about 28% of the total labour force of the country .

These figures demonstrate that the Algerian agricultural labour force bears a heavy responsibility because one agricultural labourer should produce agricultural and food products to meet his own requirements as well as those of 21 other persons . The achievement of self-sufficiency in agricultural and food products is dependent on the efficiency of the agricultural development which faces a great challenge represented in the migration of people from rural to urban areas and the decline in the agricultural labour force(1) .

1.3.4 The Present Situation of the Main Agricultural Production Inputs:

There is a marked development in the local production and use of agricultural inputs . However, this development is still far below the level required . The following is a short idea about the development of the main agriucultural production inputs :

- The number of agricultural tractors increased from 43640 in 1980 to 63071 in 1982, i.e. at an average increase of 144%. The number of harvesters increased from 5660 in 1980 to 7162

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(1) National Bureau for Statistics, Internal Migration, Algeria, 1984, P. 6 .

in 1982, i.e. at an average increase of 126% . In spite of this development the share of one tractor of the cultivable land is still high (119 ha for each tractor in 1982) . It should be noted that mechanization is being used fully by the state farms and the cooperative farms while draft animals are being greatly used by the private sector .

- The production of nitrogen and phosphate fertilizers increased from 54.6 thousand tons in 1980 to 99 thousand tons, i.e. at an average increase of 181% . However, the share of one hectare of fertilizers was lower than the required level . It averaged 12.5 kg/ha of nitrogen, 19kg/ha of phosphorus and about 16kg/ha of potash (rainfed and irrigated area, 1982) . The quantitiy of fertilizers consumed was estimated at about 10% of the requirements for the cropped area .

- The agricultural local loan (in kind and cash) increased from US$ 469 million in 1980 to US$ 494.5 million in 1982, i.e. at an average increase of 5% . The percentage of loans in kind amounted to 58.3% and 73% of the total loans in 1980 and 1982 respectively . It should be noted that the agricultural loans in 1980 were composed of 12% for plant production, 4% for livestock production and 84% for both . In 1982 they were composed of 9.7% for plant production, 2.7% for livestock production and 87.6% for both .

- The use of improved seeds and pesticides is still far below the required level . In spite of the lack of data concerning the use of these agricultural inputs one can estimate

that about one third of seeds distributed to farmers comes from unknown and low yielding varieties . The use of pesticides is limited to some agricultural crops, vegetables and fruit trees .

1.4 Crop Structure and Management of Agricultural Holdings:

The competition between plant crops for agricultural area differs from one year to another due to the effects of agricultural policies and natural conditions . Table (5) shows the relative importance of various agricultural crops and their competition for agricultural area .

Table (5) shows that the area planted with cereals ranked first . It averaged 64.2% of the total cropped area during 1981-1982 . Wheat occupied an average of 41% of the total cropped area . Wheat occupied 64% of the cereal area and 41% of the total cropped area . Barley occupied 31.2% of the cereal area and 20% of the total cropped area . Other cereal crops (rice, oat, corn, etc.) occupied only 3.2% of the total cropped area . Fruit trees occupied 26.5% of the total cropped area . It should be noted that other crops (oil seed crops) included with fruit trees in table 5 occupied only 5.3 thousand hectares . Legumes occupied 2.5% of the total cropped area, tubers 1.8%, vegetables 3.7% and forages 1.3% .

The management of agricultural holdings is controlled by three sectors, viz. the socialist sector, the agricultural revolution sector and the private sector . The cropped area differs from one sector to another . The management of the

TABLE 5: CROP STRUCTURE FOR 1981 - 1982

Cropped Area (1000ha) / Crop	1981		1982		Average of 1981 - 82	
Wheat	1813.2	40%	1638	42%	1725.6	41%
Barley	870.8	19.2%	815	21%	842.9	20%
Other cereals	152	3.3%	115	2.9%	133.5	3.2%
Total of cereals	2836	62.5%	2568	65.9%	2702	64.2%
Legumes	116.5	2.5%	98.08	2.5%	107.3	2.5%
Tubers	77	1.7%	73.4	1.9%	75.2	1.8%
Vegetables	160.6	3.5%	152.6	3.9%	156.6	3.7%
Forages	58.5	1.3%	57.7	1.3%	55.6	1.3%
Fruit trees and other crops	1294.4	28.5%	946.33	24.5%	1120.4	26.5%
Total of cropped area	4543	100%	3891.11	100%	4217.1	100%

Source:

- Year Book for Agricultural Statistics , P. 124
- Analytical Statistical Book, P. 13.

agricultural holdings is characterized by the following :

- The private sector dominates over about 50% of the total cereal area . It also dominates over more than 50% of the area planted with vegetables .

- The socialist sector dominates over 50% of the area planted with legumes . It also dominates over more than 50% of the area planted with industrial crops and more than 50% of the area planted with fruit trees . However, this percentage is now decreasing due to the expansion of fruit trees cultivation by the private sector .

- The agricultural revolution sector ranks third after the other two sectors .

- The private sector dominates over the livestock and poultry wealth . The role of the other two sectors in this field is very limited .

2. The Situation of Wheat and Barley Production :

This part will analyze the development of the area planted with wheat (durum wheat and bread wheat) and barley,the level of production and the productivity of these two crops with the aim to identify the main trends of the production and the fluctuations and deviations in these trends as well as the factors affecting the level of production . It will deal with each crop separately depending on the methods of the descriptive and quantitative analysis .

Wheat Crop

2.1 Area Planted with Wheat:

2.1.1 Development of Area Planted with Durum Wheat:

Table (6) shows that the area planted with durum wheat during 1970-1980 averaged 1444.76 thousand hectares . It ranged from a low of 1233.8 thousand hectares in 1977-78 to a high of 1651.7 thousand hectares in 1971-72 . It appears that the area planted with durum wheat fluctuated from one year to another (the standard deviation reached 136.33 thousand hectares and the variation coefficient amounted to 9%) . An equation for general trend shows the annual changes in areas planted with durum wheat (table 7) .

Table 7:

Equation	R	R2	T	test
$\hat{Y}n = 1606.73 - 29.53\ Xn$ (12.02)	-0.65	0.42	-2.45	5%=2.306 1%=3.335

Where $\hat{Y}n$ = estimated area of durum wheat in 1000 ha p.a.(n)

Xn = Years (1, 2, ...15)

TABLE 6: AREA, PRODUCTION AND PRODUCTIVITY OF DURUM WHEAT IN ALGERIA

Cropping Season	Area (1000 ha)	Production (1000 t.)	Productivity (kg / ha)
1969/70	1563.7	914	584
1970/71	1381.9	794	574
1971/72	1651.7	911.9	552
1972/73	1541.0	698.5	453
1973/74	1413.2	630.9	446
1974/75	1483.4	1181.0	796
1975/76	1560.2	1035.6	664
1976/77	1301.7	573.3	440
1977/78	1233.8	702.4	569
1978/79	1317.0	707.8	537
1979/80	---	926.5	---
Mean	1444.76	825.08	561.50
Standard Deviation	136.33	185.37	108.92
Variation Coefficient	9%	22%	19%

The estimates of the above equation shows that its regression coefficient was negative and significant . This means that the area planted with durum wheat decreased during the study period at an annual rate of 29.53 thousand hectares, i.e. about 2% of the average of area planted with durum wheat which amounted to about 1444.76 thousand hectares . Plot (1) shows the general trend of the area planted with durum wheat .

2.1.2 Development of the Area Planted with Bread Wheat:

Table (8) shows that the area planted with bread wheat averaged 726 thousand hectares during 1970-1980 . It ranged from a low of 605.2 thousand hectares in 1976/77 to a high of 819.3 thousand hectares in 1971/72 .

It appears that the area planted with bread wheat during the study period fluctuated from one year to another (the standard deviation amounted to 77.63 thousand hectares and the variation coefficient reached 10%). It should be noted that fluctuations in area planted with bread wheat are greatly similar to those in areas planted with durum wheat noting that the variation coefficient for both areas was almost the same during the study period . An equation for the general trend of the area planted with bread wheat shows the changes in this area during the study period .

TABLE 8: AREA, PRODUCTION AND PRODUCTIVITY OF BREAD WHEAT IN ALGERIA

Cropping Season	Area (1000 ha)	Production (1000 t.)	Productivity (kg / ha)
1969/70	743.2	520.5	700
1970/71	766.1	523.4	683
1971/72	819.3	743.9	908
1972/73	805.8	459.5	570
1973/74	787.7	460.1	584
1974/75	739.3	666.7	902
1975/76	734.9	594.0	808
1976/77	605.2	253.8	419
1977/78	630.6	380.5	603
1978/79	628.5	372.6	593
1979/80	---	584.9	---
Mean	726.06	505.44	677
Standard Deviation	77.63	140.82	156.67
Variation Coefficient	10%	28%	23%

TABLE 9:

Equation	R	R2	T	test
$\hat{Y}n=836.5 - 20.1\ Xn$ (5.64)	-0.78	0.61	-3.56	5%=2.306 1%=3.355

Where $\hat{Y}n$ = Estimated bread wheat area (1000 ha) p.a. (n) .

Xn = Years of study (1, 2, ...15) .

The estimates of the above equation show that its regression coefficient was negative and significant . This means that the area planted with bread wheat decreased at a rate of 20.1 thousand hectares annually during the study period, i.e. about 2.76% of the mean of the area planted with bread wheat which amounted to 726 thousand hectares . Plot (2) shows the general trend of area planted with bread wheat .

2.1.3 Development of Area Planted with Wheat :

The area planted with wheat in Algeria during 1970-82 (table 10) averaged 2093.2 thousand hectares . It ranged from a low of 1638 thousand hectares in 1981-82 to a high of 2471.2 thousand hectares in 1971/72 . It appears that the area planted with wheat fluctuated from one year to another and this was due to the rainfed conditions prevailing in wheat areas . By calculating the range of scattering in the area planted with wheat during the study period we find that the standard deviation amounted to 245.2 thousand hectares and the variation coefficient reached 11.7% .

TABLE 10: AREA, PRODUCTION AND PRODUCTIVITY OF WHEAT IN ALGERIA

Year	Area (1000 ha)	Production (1000 t)	Productivity (kg / ha)
1969/70	2306.9	1434.5	622
1970/71	2148.1	1317.4	613
1971/72	2471.2	1655.8	670
1972/73	2346.9	1158.1	493
1973/74	2200.9	1091.1	496
1974/75	2222.8	1847.8	831
1975/76	2295.1	1629.7	710
1976/77	1906.9	827.1	434
1977/78	1864.5	1083.0	581
1978/79	1945.5	1080.4	555
1979/80	2051.3	1511.5	737
1980/81	1813.2	1218.4	672
1981/82	1638.0	977.0	596
Mean	2093.2	1294.75	616.15
Standard Deviation	245.2	301.64	109.46
Variation Coefficient	11.7%	23%	18%

The equation for the general trend of area planted with wheat shows the annual change which occurred in this area .

Table 11:

Equation	R	R2	T	test
$\hat{Y}n = 2460.7 - 52.5\ Xn$ (10.5)	-0.83	0.69	-5.02	5%=2.201 1%=3.106

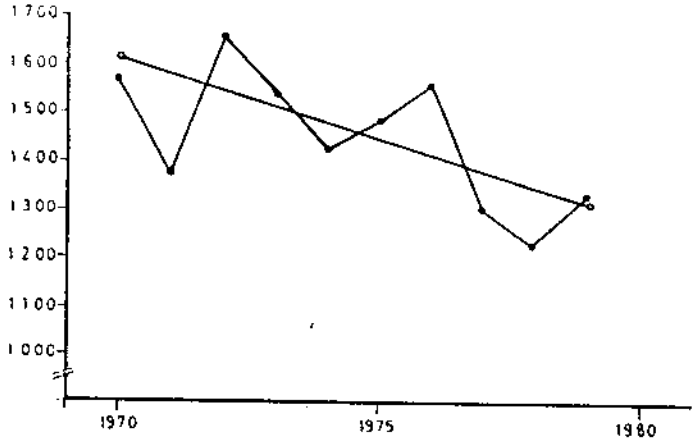
Where $\hat{Y}n$ = Area planted with wheat p.a. (1000 ha) (n) .

Xn = Years of study period (1, 2, ...13) .

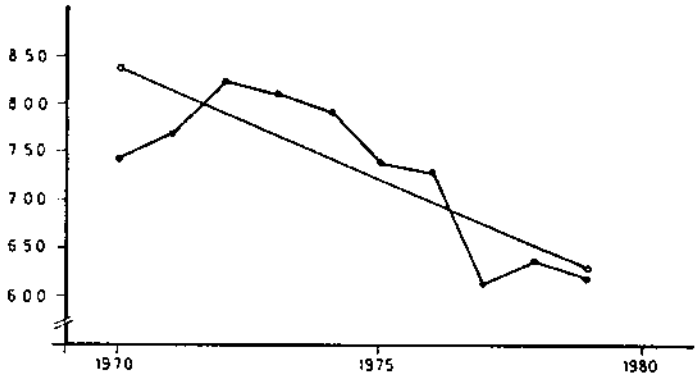
The regression coefficient of the above equation is negative and significant at 1% level . This means that the area planted with wheat decreased at a rate of 52.5 thousand hectares annually, i.e. about 2.5% of the average area planted with wheat which amounted to about 2093.2 thousand hectares . Plot (3) shows the general trend of the area planted with wheat .

2.1.4 Effect of Wheat Prices on Area Planted with Wheat:

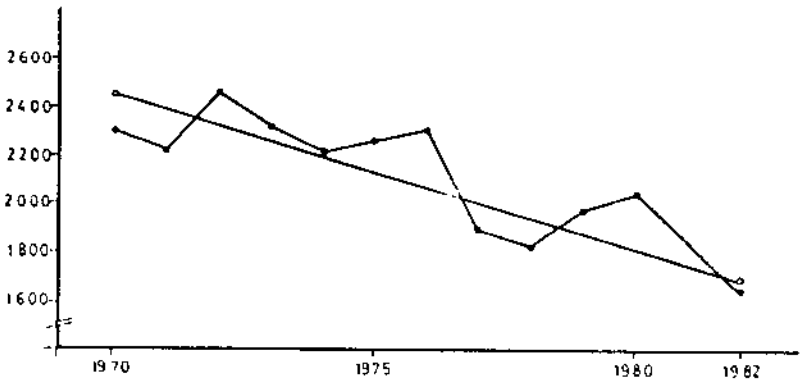
The economic factors affect the area planted with wheat and dertmine the net farm income (total income - total costs) . This economic indicator is one of the main factors which contribute to the expansion or decrease of area planted with agricultural crops in general and crops competing for agricultural area (such as wheat and barley) in particular . In Algeria , the government predetermines wheat prices prior to planting . This policy affect the area planted with wheat during the cropping season . It may also produce a positive or negative effect on this area during the coming season . Because of the



Plot 1: General Trend of Area Planted with Durum Wheat (1000ha) .



Plot 2: General Trend of Area Planted with Bread Wheat (1000 ha) .



Plot 3 : General Trend of Area Planted with Wheat (1000 ha) .

lack of data concerning the farm net income for unit area planted with wheat or for competing crops the wheat farm price considered as an economic indicator to determine its effect on changes in areas planted with wheat . Table (12) shows the relationship between wheat farm prices and areas planted with wheat during 1974/75 - 1981/82 .

TABLE 12:

Equation	R	R2	T	test
$\hat{Y}n = 2671.1 - 7.1\ Xn$ (2.04)	-0.82	0.67	3.44	5%=2.447 1%=3.707

Where $\hat{Y}n$ = Area planted with wheat p.a (1000 ha) (n) .
Xn = Farm price for one Knatar of wheat in Algerian Dinars for years of study (1, 2, ...8)

The results of the above equation show that :

- There is a strong and reverse correlation between area planted with wheat and wheat farm prices . (Correlation coefficient amounted to (-0.82) .

- The area planted with wheat decreased at a rate of 7.1 thousand hectares annually . This decrease is significant at 5% level .

- The farm prices of a wheat kantar during the study period contributed greatly to the decrease in the area planted with wheat (R2 amounted to 67%) . This means that decrease in area planted with wheat is 67% due to the prevailing farm

prices while the remaining 33% were due to other factors not included in the analysis of the estimated equation .

The existence of such a reverse relationship between wheat farm prices and area planted with wheat requires that the pricing policy for this important and strategic crop should be reconsidered and that wheat prices should be linked with the cost of production . The adoption of such measures is necessary in order to halt the decrease in area planted with wheat and allow wheat growers to acquire the requirements needed to improve the level of production in the unit area . Undoubtedly, the net income received by farmers and the level of loans (cash and in kind), taxes and incentives all these play an important role in the adoption of the above measures .

2.2.1 Development of Durum Wheat Productivity per Hectare:

Table (6) shows that productivity per hectare of durum wheat was low in all the years of study . It averaged 561.5 kg/ha . It ranged from a low of 440kg/ha in 1976/77 to a high of 796 kg/ha in 1974/75 . It appears that wheat productivity fluctuated sharply from one year to another . (The variation coefficient reached 19% while the standard deviation amounted to 108.9 kg/ha) .

An equation for the general trend of durum wheat productivity per hectare shows the changes which occurred annually in this productivity (table 13) .

TABLE 13:

Equation	R	R2	T	test
$\hat{Y}n = 563.5 - 0.001\ Xn$	-0.02	0.0004	0.008	5%=2.306
(0.12)				1%=3.355

Where $\hat{Y}n$ = Durum wheat productivity per hectare (in kg)(n) .

Xn = Years of study (1, 2, ...10) .

It appears that the regression coefficient of the above equation is negative and insignificant . This means that the annual changes which occurred in wheat productivity were not significant . Plot (4) shows the general trend of durum wheat productivity per hectare .

2.2.2 Development of Bread Wheat Productivity per Hectare:

Table (8) shows the bread wheat productivity per hectare during 1970-80 . It appears that this productivity was not better than that of the durum wheat . It averaged 677 kg/ha and ranged from a low of 419 kg/ha in 1976-77 to a high of 908 kg/ha in 1971/72 . It appears also that bread wheat productivity per hectare fluctuated sharply from one year to another. (The variation coefficient reached 23%) . We conclude that fluctuations in bread wheat productivity per hectare are greater than those in durum wheat productivity during the study period .

An equation for the general trend of bread wheat productivity per hectare shows the annual changes which occurred in this productivity (table 14) .

TABLE 14:

Equation	R	R2	T	test
$\hat{Y}n = 774.7 - 0.18\ Xn$ (0.17)	-0.34	0.11	1.06	5% = 2.306 1% = 3.355

Where $\hat{Y}n$ = Estimated bread wheat productivity kg/ha/year (n) .

Xn = Years of study (1, 2, ...15) .

It appears that the regression coefficient of the equation is negative and not significant . This means that the changes which occurred in the bread wheat productivity during the study period were not significant . Plot (5) shows the general trend of bread wheat productivity per hectare .

2.2.3 Development of Wheat Productivity per Hectare :

Wheat productivity per hectare was very low during the years of study (table 10) . It ranged from a high of 831 kg/ha in 1974/75 to a low of 434 kg/ha in 1976/77 . Therefore, Algeria is considered as having low wheat productivity just like the other countries in the Arab Maghreb(1) . Moreover, this productivity fluctuates sharply from one year to another . (Standard deviation = 109 kg/ha and variation coefficient = 18%) . All possible measures should be taken in order to increase and stabilize wheat productivity . This can be achieved through the adoption of modern practices such as the replacement of low yielding local varieties with improved varieties which are adapted to local conditions, the use of fertilizers etc .

An equation for the general trend shows the changes which occurred in wheat productivity per hectare during the study period (table 15) .

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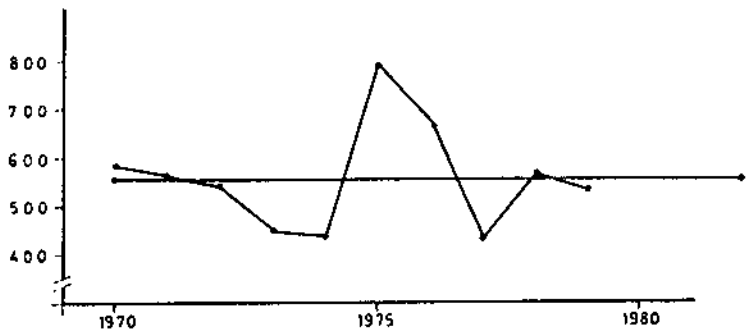
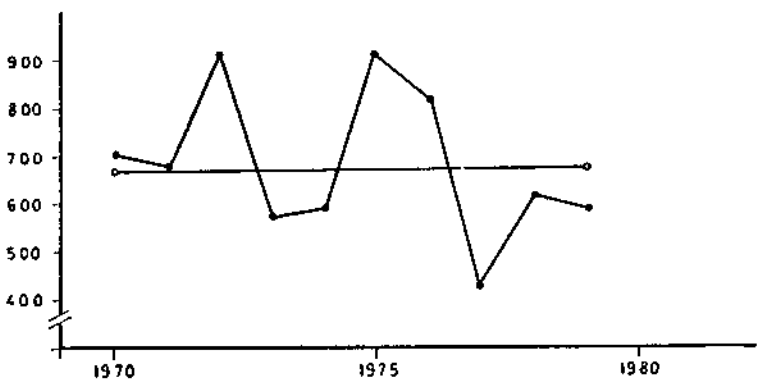
(1) The average wheat productivity per hectare in Libya is 380 kg/ha, Tunisia 680 kg/ha, Morocco 900 kg/ha and Algeria 616 kg/ha .



Plot 4 : General Trend of Durum Wheat Productivity (kg/ha) .



Plot 5 : General Trend for Bread Wheat Productivity (kg/ha) .

TABLE 15:

Equation	R	R2	T	test
$\hat{Y}n = 602 + 2.01\ Xn$ (8)	0.07	0.0049	0.25	5% = 2.201 1% = 3.106

Where $\hat{Y}n$ = Estimated wheat productivity kg/ha/year (n) .

Xn = Years of study (1, 2, ...13) .

It appears that the regression coefficient of the above equation is positive and not significant . This means that the changes in the wheat productivity from one year to another are not significant . Plot (6) shows the general trend of wheat productivity per hectare .

2.3 Wheat Production:

2.3.1 Development of Durum Wheat Production:

Table (6) shows that durum wheat production during 1970-1980 averaged 825.08 thousand tons . It ranged from a low of 573.3 thousand tons in 1976-77 to a high of 1181.0 thousand tons in 1974/75 . It appears also that durum wheat production fluctuated sharply from one year to another (standard deviation = 185.3 thousand tons and variation coefficient = 22%) . The fluctuations in the durum wheat production in the study period are greater that those in the area planted with durum wheat by two and a half folds . Undoubtedly, there is a great need to cope with this serious situation in order to increase and stabilize wheat production . The adoption of improved cultural practices such as the introduction of high yielding varieties which are adopted to local conditions would be the best solution . An

equation for the general trend shows the annual changes in durum wheat production (table 16) .

Table 16:

Equation	R	R2	T	test
$\hat{Y}n = 866.3 - 6.9\ Xn$ (18.5)	-0.12	0.014	0.37	5%=2.262 1%=3.250

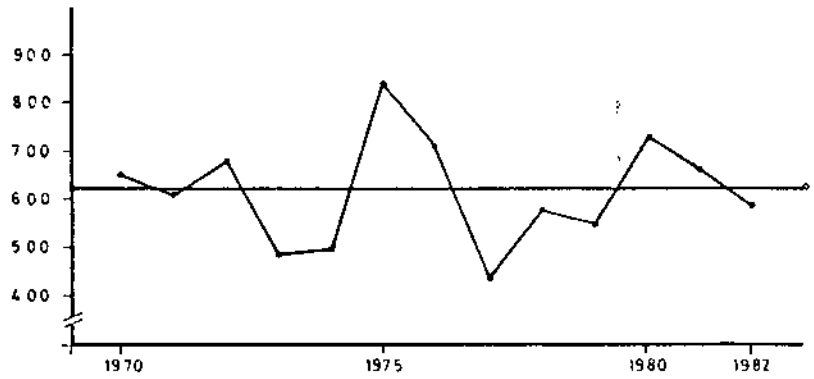
Where $\hat{Y}n$ = Estimated durum wheat production (1000 t/year) (n) .

Xn = Years of study (1, 2, ...11) .

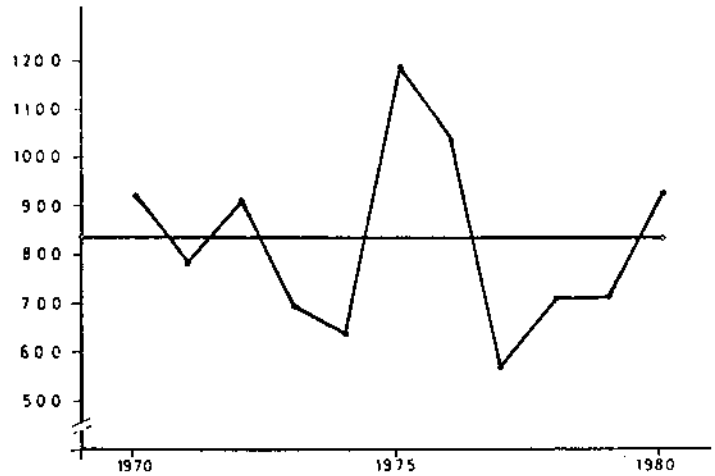
It appears that the regression coefficient of the above equation is negative and not significant . This means that the annual changes in durum wheat production are not significant . Plot (7) shows the general trend of durum wheat production .

2.3.2 Development of Bread Wheat Production :

Table (8) shows that bread wheat production during 1970-80 averaged 505.44 thousand tons. It ranged from a low of 253.8 thousand tons in 1976/77 to a high of 743.9 thousand tons in 1971/72 . It shows also that bread wheat production fluctuated sharply from one year to another (standard deviation = 140.8 thousand tons and variation coefficient = 28%) . The fluctuations in bread wheat production were greater than those in area planted with bread wheat by three folds . These indicators stress the need to take all possible measures to increase and stabilize production of durum and bread wheats . An equation for the general trend shows the changes occurred



Plot 6 : General Trend of Wheat Productivity (kg/ha) .



Plot 7 : General Trend of Durum Wheat Production (1000t.) .

in local wheat production during the study period (table (17) .

TABLE 17:

Equation	R	R2	T	test
$\hat{Y}n = 657.95 - 24\ Xn$ (11.7)	-0.56	0.31	2.04	5%=2.262 1%=3.25

Where $\hat{Y}n$ = Estimated bread wheat production (1000t/year)(n).
Xn = Years of study (1, 2, ...11) .

It appears that the regression coefficient of the above equation is negative and significant . This means that there was a decrease in bread wheat production at an average of 24 thousand tons annually, i.e. about 4.6% of the mean of bread production which amounted to 505.44 thousand hectares during the study period . Plot (8) shows the general trend of bread wheat production .

2.3.3 Development of Wheat Production:

Table 10 shows that wheat production during 1970-82 averaged 1294.75 thousand tons . It ranged from a low of 827.1 thousand tons in 1976/77 to a high of 1847.8 thousand tons in 1974/75. It appears that fluctuations in wheat production were greater than those in area planted with wheat by one fold . This situation was due to the rainfed conditions prevailing on wheat cultivation in Algeria . It appears also that in many cases the large areas planted with wheat gave less wheat production (bread and durum wheats) as shown in tables 6, 8, 10 . Amount of rainfall and rain distribution affect production of wheat in the

unit area . Low productivity of seeds of local varieties also affect wheat production (rainfall averages are relavely high in most rainfed crop production regions)(1).

An equation for the general trend shows the annual changes which occurred in wheat production during the study period (table 18) .

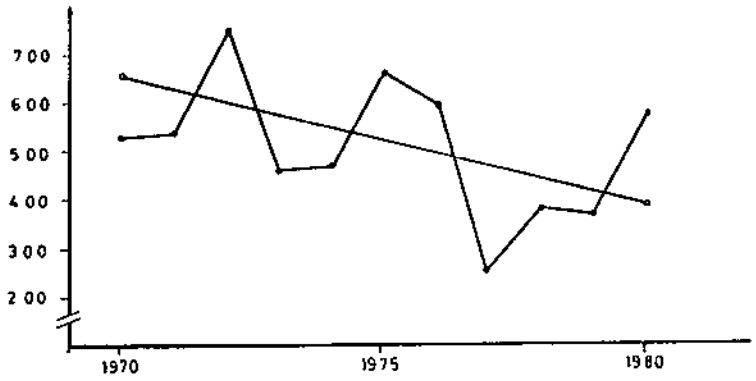
TABLE 18:

Equation	R	R2	T	test
$\hat{Y}n = 1490.4 - 27.95\ Xn$ (21.78)	-0.03	0.0009	-1.28	5%=2.201 1%=3.106

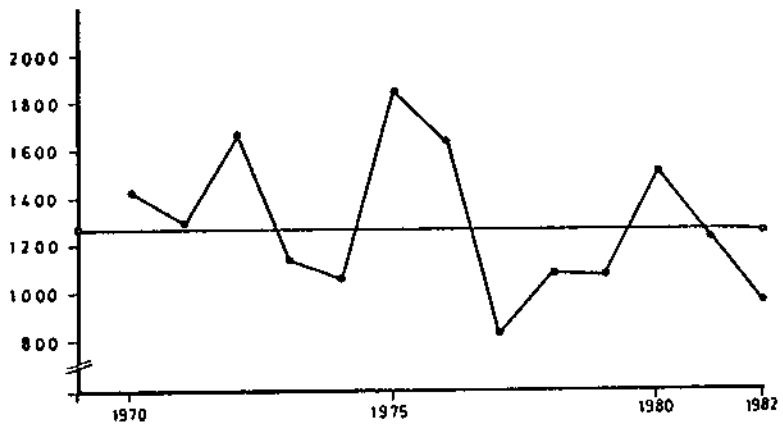
Where $\hat{Y}n$ = Estimated wheat production, 1000 t/year (n) .
Xn = Years of study (1, 2, ...13) .

It appears that the regression coefficient of the above equation is negative and insignificant . This means that the changes which occurred in wheat production during the study period were not significant . Plot (9) shows the general trend of wheat production .

(1) This subject will be discussed in detail later .



Plot 8 : General Trend of Bread Wheat Production (1000t.) .



Plot 9 : General Trend of Wheat Production (1000t.) .

3. BARLEY CROP

3.1. Development of Area Planted with Barley:

The study of table (19) shows that the area planted with barley during 1970-82 averaged 818.56 thousand hectares . It ranged from a minimum of 666.5 thousand hectares in 1977/78 to a maximum of 948.3 thousand hectares in 1971/72 . It appears that the area planted with barley fluctuated sharply from one year to another . These fluctuations were due to various factors the most important of which was the prevailing rainfed farming conditions which affect crop production positively or negatively . The calculation of the range of scattering in the area planted with barley during the study period shows that standard deviation reached 93.93 thousand hectare while variation coefficient was 11.5% . An equation for the general trend shows the annual changes which occurred in the area planted with barley (table 20) .

TABLE 20:

Equation	R	R2	T	test
$\hat{Y}n = 804.35 + 2.3\ Xn$ (7.2)	0.006	0.00036	0.32	5%=2.201 1%=3.106

Where $\hat{Y}n$ = Estimated area planted with barley 1000 ha/year (n) .
Xn = Years of study (1, 2, ...13) .

It appears that the regression coefficient of the above equation is positive and insignificant . This means that the changes which occurred in the area planted with barley were not significant . These changes were merely fluctuations around the mean . Plot (10)

TABLE 19: AREA, PRODUCTION AND PRODUCTIVITY OF BARLEY IN ALGERIA

Year	Area (1000 ha)	Production (1000t)	Productivity (kg/ha)
1969/70	854.7	571.4	668
1970/71	728.2	371.8	510
1971/72	948.3	644.0	679
1972/73	785.6	373.7	476
1973/74	690.2	331.4	480
1974/75	854.7	742.7	869
1975/76	932.3	588.7	631
1976/77	741.5	260.5	315
1977/78	666.5	397.0	596
1978/79	808.9	456.6	564
1979/80	944.6	794.2	841
1980/81	870.8	524.8	603
1981/82	815.0	483.0	593
Mean	818.56	526.12	604.7
Standard Deviation	93.93	190.34	142.36
Variation Coefficient	11.5%	36%	23%

shows the general trend of area planted with barley .

3.1.1 Effect of Barley Prices on Area Palnted with Barley:

An analysis of the relationship between barley farm prices and area planted with barley during 1974/75-1981/82 gives the results as shown in table (21) .

TABLE 21:

Equation	R	R2	T	test
$\hat{Y}n = 781.66 + 0.73\ Xn$ (2.33)	0.13	0.016	0.31	5%=2.447 1%=3.707

Where $\hat{Y}n$ = Estimated area planted with barley 1000ha/year (n)
Xn = Farm price of one kantar of barley during years of study (1, 2, ...8) .

It appears that the regression coefficient of the above equation is positive and not significant . This means that barley farm prices per kantar during the study period had no significant effect on the annual changes which occurred in the area planted with barley . It should be noted that the changes which occurred in the area planted with barley during the study period had no constant general trend as seen in the analysis of the relationship between the area planted with barley and the time (table 20) . We conclude that the annual changes in the area planted with barley were due to several factors other than prices and time . It seems that climatic factors, particularly rainfall, play an important role in directing changes in areas planted with barley crop .

3.2 Development of Barley Productivity per Hectare:

The figures in table (19) suggest that barley productivity during the study period was low .It averaged 604.7 kg/ha and ranged between a minimum of 351 kg/ha in 1976/77 to a maximum of 869 kg/ha in 1974/75 . Barley productivity in Algeria, like in other Maghreb Arabi countries(1), is considered low and variable (standard deviation = 142.36 kg/ha and variation coefficient = 23%) . This situation requires that the agricultural policy concerning this crop should be reconsidered and that all possible measures should be taken with the objective to increase production in the unit area . One of important measures would be the introduction of the seeds of improved varieties to replace the local varieties which give low yield . An equation for the general trend shows the changes which occurred in the area planted with barley during the study period (table 22) .

TABLE 22:

Equation	R	R2	T	test
$\hat{Y}n = 580.1 + 3.52\ Xn$	0.09	0.0081		5% = 2.201 1% = 3.106

Where $\hat{Y}n$ = Barley productivity kg/ha p.a. (n) .
Xn = Years of study (1, 2, ...13) .

It appears that the regression coefficient of the above equation is negative and insignificant . This means that the changes

(1) Barley average productivity per hectare in Libya 450kg/ha, in Tunisia 510kg/ha and in Morocco 960kg/ha .

which occurred in barley productivity per hectare during the study period were not significant . They were merely fluctuations around the mathematical mean . Plot (11) shows the general trend of barley productivity per hectare .

3.3 Development of Barley Production:

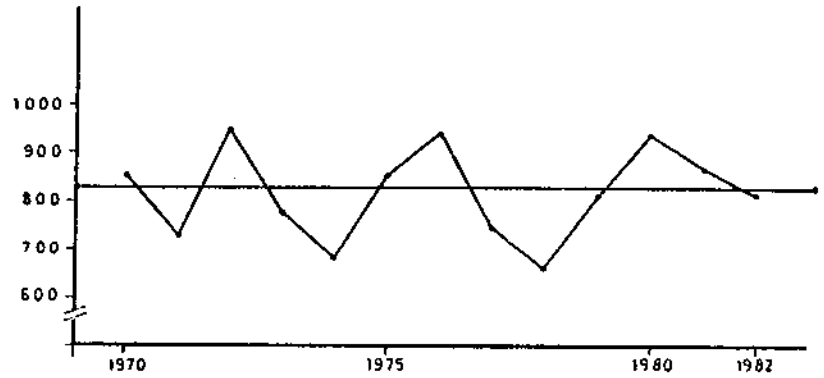
The study of table (19) shows that barley production during 1970-82 averaged 526.2 thousand hectares and ranged between a minimum of 260.3 thousand hectares in 1976/77 and a maximum of 794.2 in 1979/80 . It appears that barley production fluctuated from one year to another (standard deviation = 190.34 thousand tons and variation coefficient = 36%) . A comparison between barley production and area planted with barley during the study period shows that barley production fluctuated threefold compared to the area planted with barley . This situation is not to the advantage of the production of barley crop . Undoubtedly, this situation is due to several factors the most important of which are the rainfed farming conditions prevailing on barley production . Rainfall and rain distribution are among the factors affecting production in the unit area . An equation for the general trend shows the annual changes in barley production (table 23) .

TABLE 23:

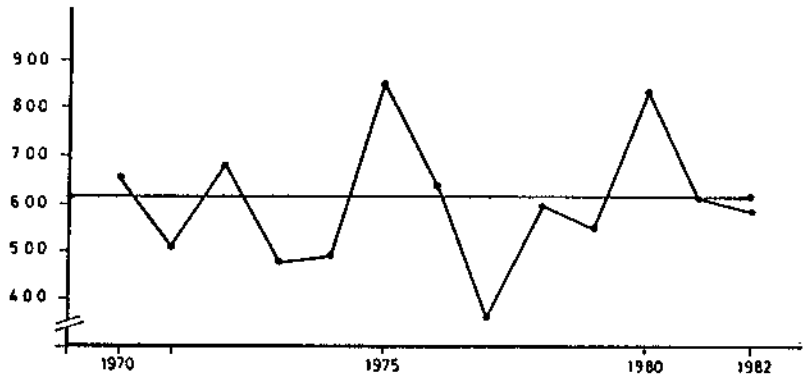
Equation	R	R2	T	test
$\hat{Y}n = 578.7 - 7.5\ Xn$	-0.15	0.02	0.52	5% = 2.201
(14.5)				1% = 3.106

Where $\hat{Y}n$ = Barley production (1000t) p.a. (n)

Xn = Years of study (1, 2, ...13) .

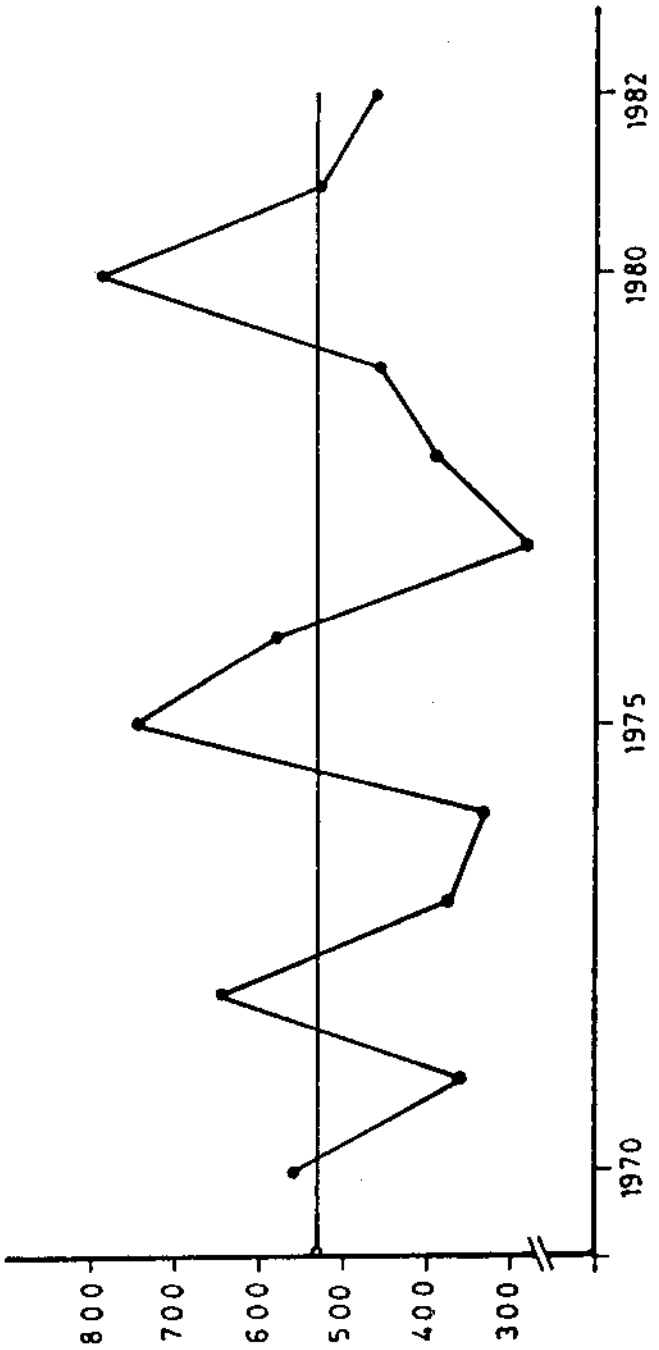


Plot 10 : General Trend of Area Planted with Barley (1000 ha) .



Plot 11 : General Trend of Barley Productivity (kg/ha) .

It appears that the regression coefficient of the above equation is negative and insignificant . This means that the annual changes which occurred in barley production during the study period were not significant but merely fluctuations around the mathematical mean . Plot (12) shows the general trend of barley production .



Plot 12 : General Trend of Barley Production (1000t.) .

4. Rainfall:

The analytical study of the situation of wheat and barley crops shows the sharp fluctuations in the production of these two crops during the period 1970-82 . We have noticed that these fluctuations were due to the deviations which affected the area planted with wheat and barley on the one hand and the fluctuations in wheat and barley productivity per hectare on the other hand . These fluctuations are attributed to various factors such as the ecological factors which play an important role in the changes which occur in the agricultural production in general and in the rainfed crop production in particular . Therefore, it is important to identify the rainfall trends and fluctuations as well as rainfall cycle .

4.1 Classification of Algeria into Regions According to Rainfall Efficiency:

Amount of rainfall differs from one region to another . Rain distribution differs also in the same region during the successive years . In spite of fluctuations in rainfall from one year to another one can note that geographical regions are characterized by a certain level of absolute or relative rainfall efficiency .

The following study dealt with the rainfall efficiency for different regions . The results led to the possibility to classify Algeria into two rainfall regions according to certain limits (table 24) .

Table (24) shows that :

TABLE 24:

Region	Station	Average Rainfall mm.	Standard Number
First	Bujaya	863	166
Region	Skikda	751	145
450 mm	Algiers	732	141
and more	Malyana	705	136
	Anaba	658	127
	Constantine	592	114
Second	Talmasan	454	88
Region	Stef	386	74
300-400mm.	Tabsa	384	74
	Al-Jalfa	361	70
	Saida	360	69
	Wahran	357	69
	Batna	326	63
	Al-Asnam	325	63
Mean	---	518.14	100

The first rainfall region includes the areas relating to the rainfall stations of (Bujaya, Skikda, Algiers, Malyana, Anaba and Constantine) in which the standard number of the average rainfall exceeds 100 and which in turn represent the mean of the annual average of rainfall at the level of Algeria .

The second rainfall regions includes the areas relating to the rainfall stations of (Talmasan, Stef, Tabsa, Al-Jalfa, Saida, Wahran, Batna and Al-Asnam) . The standard number of the average rainfall is less than 100 for each area .

4.2 Fluctuations in Rainfall :

All these areas experience fluctuations in rainfall in spite of the rainfall efficiency for some areas . This situation affect directly the rainfed crops, especially when fluctuations occur in the period when the plants require water during growth stages . A general framework has been drawn up for these fluctuations according to standard indicators as shown in table (25) .

The study of table (25) shows that the variation coefficient for the annual rainfall fluctuations during the study period amounted to 16% at the country level . The variation coefficient for the rainfall fluctuations ranged from a minimum of 11% in the area related to Al-Jalfa station to a maximum of 59% in the area related to Al-Asnam station . After excluding the two areas related to the Constantine and Al-Jalfa stations we find that rainfall fluctuations in other areas were relatively high . High rainfall in most regions in Algeria moderates the effects resulting from rainfall fluctuations . Under this situation it is advisable to exploit Algerian lands through the redistribution of rainfed crop lands

TABLE 25: FLUCTUATIONS IN RAINFALL ACCORDING TO VARIATION COEFFICIENT FOR ALGERIAN REGIONS DURING 1979-1982

Station	Average Rainfall mm.	Standard Deviation	Variation Coefficient%
Al-Asnam	325	193	59
Malyana	705	285	40
Stef	386	140	36
Bujaya	863	297	32
Tabsa	384	124	32
Wahran	357	114	32
Saida	360	109	30
Skikda	751	220	29
Batna	326	91	28
Algiers	732	205	28
Anaba	658	169	25
Talmsan	454	101	22
Constantine	592	92	15
Al-Jalfa	361	42	11
Mean	518.14	83	16

according to rainfall efficiency and the relative importance of various crops taking into consideration the nature of these lands . It should be noted that wheat and barley productivity is low in most of Algeria . It averaged 616 kg/ha while the maximum was 870 kg/ha during the study period in spite of the good rainfall in most of the agricultural regions . This means that there were other factors which affected wheat and barley productivity . Therefore it is important to improve wheat and barley productivity through the intoduction of high yielding varieties to replace the local varieties which give low yield . The adoption of improved practices would halt the decline in productivity which amounted to 18% in wheat and 23% in barley during the study period and then would improve and stabilize this productivity .

It should be noted in this respect that ACSAD has played an important role, through its studies and the Cereal Development Project, in the production of the seeds of improved varieties which are high yielding and adapted to ecological conditions . Undoubtedly, the increase of cooperation between ACSAD's experts and the national experts would lead to the improvement of the production of wheat and barley .

4.3 Classification of Algerian Lands According to Homogeneous Rainfall Areas:

Having identified the rainfall efficiency for various parts of Algeria and the fluctuations in rainfall we analyzed the differences between rainfall averages for different areas in Algeria in order to dermine whether these differences were significant or not .

For this objective we conducted a variation analysis for rainfall averages during the period 1979-82 . The analysis shows significant differences [1] between various areas .

By making a comparison between rainfall averages for different areas it was possible to identify the significant differences (estimated minimum of LSD[2], table (26) .

The Algerian areas were classified into 3 homogeneous rainfall groups (table 27) .

TABLE 27:

Group	Station
A	
More than 600mm.	Bijaya, Skikda, Algiers, Malyana and Anaba
B	
360 - 600mm	Constantine, Talmsan, Stef, Tabsa, Al-Jalfa and Saida
C	
Less than 360 mm	Wahran, Batna and Al-Asnam

(1) Calculated F = 4.55, F from tables = 1.98 and 2.63 at 5% and % level respectively according to degree of freedom 13 and 37 .

(2) LSD = 234, 314 at 5% and 1% respectively .

: 26: DIFFERENCES BETWEEN RAINFALL AVERAGES IN DIFFERENT STATIONS IN ALGERIA 1979-1982

on	Bijaya	Skikda	Algiers	Melyana	Anaba	Constantine	Talmsan	Stef	Tabsa	Al-Jalfa	Saida	Wahran	Batna	Al-Asnam
ge all mm	863	751	731	705	658	592	454	386	384	361	360	357	326	325
a	--													
a	112	--												
rs	131	19	--											
na	158	46	27	--										
	205	93	74	47	--									
antine	271^{x}	159	140	113	66	--								
an	409^{xx}	297^{xx}	278^{xx}	251^{x}	204	138	--							
	477^{xx}	365^{xx}	346^{xx}	319^{xx}	272^{xx}	206	68	--						
	479^{xx}	367^{xx}	348^{xx}	321^{xx}	274^{xx}	208	70	2	--					
lfa	502^{xx}	390^{xx}	371^{xx}	344^{xx}	297^{x}	231	93	25	23	--				
	503^{xx}	391^{xx}	372^{xx}	345^{xx}	298^{x}	232	94	26	24	1	--			
n	506^{xx}	394^{xx}	375^{xx}	348^{xx}	301^{x}	235^{x}	97	29	27	4	3	--		
	537^{xx}	425^{xx}	406^{xx}	379^{xx}	332^{xx}	266^{x}	128	60	58	35	34	31	--	
nam	538^{xx}	426^{xx}	407^{xx}	380^{xx}	333^{xx}	267^{x}	129	61	59	36	35	32	1	--

ignificant difference at 5% level

ignificant difference at 1% level .

Table (27) shows that each group includes stations in which there were no significant differences between rainfall averages while significant differences were found between stations belonging to different groups .

4.4 Rainfall Cycle:

The general trend of rainfall averages, the fluctuations in rainfall from one year to another, the rainfall efficiency and homogeneous rainfall areas all these indicators provide a clear picture about rainfall characteristics in different areas and allow regional planning to be more effective in the field of rainfed crop production in particular and agricultural production in general . An equation for the general trend of rainfall averages shows the annual changes which occurred in rainfall averages (table 28) .

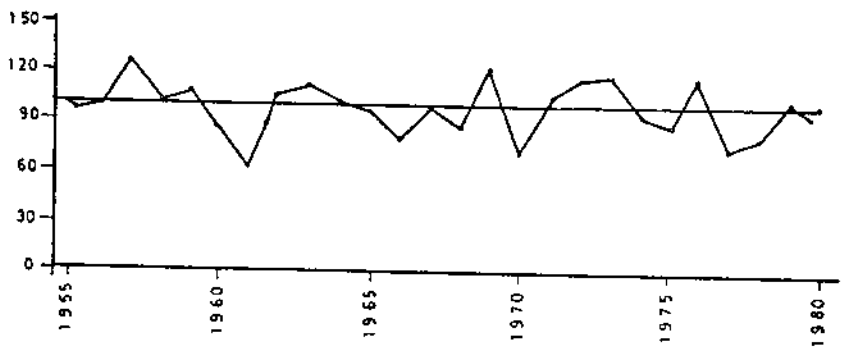
TABLE 28:

Equation	R	R2	T	test
$\hat{Y}n = 0.997 + 0.0001\ Xn$ (0.004)	0.005	0.00002	0.025	5%=2.064 1%=2.797

Where $\hat{Y}n$ = Standard number for average rainfall p.a.(n) .
Xn = Years of study (1, 2, ...26) .

It appears that there was no relationship between rainfall averages and time (R was very small) and that the average annual change in rainfall was not significant . This means that there was no constant general trend for rainfall averages but merely small fluctuations arount the mean .

Plot (13) shows the scattering of standard numbers for annual rainfall averages . It appears that most of the observed years were characterized by high rainfall averages . Fluctuations in rainfall from one year to another may affect rainfed crop production particularly during bad rain distribution in periods when plants require water . Therefore, it is important to draw up an integrated program for early warning in order to collect environmental information prior to planting season . Such a program would ensure opportunities to make sound agricultural planning and take appropriate production decisions for rainfed farming .



Plot 13 : Rainfall Cycles

5. Main Factors Affecting Wheat and Barley Production:

The pattern of agricultural exploitation in the areas planted with wheat and barley affect the level of production in the unit area . Climatic factors play an important role in the effect on the level of productivity per hectare but certain measures can limit this effect . In order to identify the effect of various factors on wheat and barley productivity per hectare we would highlight some of the important indicators as established by ACSAD through its research and studies to develop cereal production areas in Algeria (1) .

5.1 Effect of Annual Rainfall Averages :

Rainfall averages differ from one year to another and from one area to another . Fluctuation in rainfall affect productivity of wheat and barley in different areas . The results have shown that a change of 100 mm. in annual rainfall would change productivity by 700kg/ha for wheat and 600 kg/ha for barley .

The analytical and statistical study proved the existence of a strong relationship between annual rainfall averages and production in the unit area for wheat and barley . Table (29) shows the results of the study .

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(1) These include Tiaret, Kharoub, Sidi Belabbas and Stef .

TABLE 29:

Equation		R	R2	S.S.E.
$\hat{Y} = -128 + 5.2\ X$	Wheat	0.56	0.31	849kg/ha
$\hat{Y} = 306 + 5.7\ X$	Barley	0.50	0.25	1072kg/ha

Where $\hat{Y}$ = Production in the unit area (kg)

X = Rainfall averages (mm) .

We conclude from the above equation that an increase of 1mm. in annual rainfall average would increase production by 5.2 kg/ha for wheat and 5.7 kg/ha for barley . We conclude also that barley production under dry condition is better than wheat and that barley is less sensitive to fluctuations in rainfall compared to wheat .

5.2 Effect of Rain Distribution:

Sometimes annual rainfall averages are not considered as a decisive factor affecting the level of production because under high rainfall production in the unit area may deviate from its expected level compared to that under low rainfall . This may be due to poor distribution of rainfall particularly during the time when plants require water . However, productivity in the unit area may reach high levels under low rainfall compared to other years of high rainfall . This may be due to good distribution of rainfall during the time when plants require water . Several study were conducted to determine the effect of rain distribution on the level of productivity of wheat and barley . These studies reveals that a change in rainfall during the critical periods

when plants require water would affect the level of production in the unit area .

The following are the important results of the studies :

- The rain during December and January are important for the first stage of plant life (germination) . The rain during February, March and April are also important for plant because these months represent the stage of plant growth . Equation in table 30 shows the effect of rainfall on wheat and barley production during these periods .

TABLE 30:

Equation		R	R2	S.E.E.
$\hat{Y}$= -50+3.5X1+4X2+9.95X3	Wheat	0.80	0.64	763 kg / ha
$\hat{Y}$n=646+3.8X1+8.8X2-0.02X3	Barley	0.54	0.29	1050 kg / ha

Where $\hat{Y}$ = Production in unit area (kg) .
X1= Total rainfall during December + January (mm.)
X2= Total rainfall during February (mm.)
X3= Total rainfall during March and April (mm.) .

The importance of rain distribution on production of wheat and barley can be summarized as follows :

- The importance of rainfall during December and January for both crops . An increase of 1mm. of rainfall during these two months would increase production by 3.5kg/ha for wheat and 3.8 kg/ha for barley .

- The difference in the relative importance of February rain for both crops because February rain constituted a decisive factor for production of barley and that an increase of 1mm. of rainfall would increase barley production by 8.8 kg/ha . An increase of 1mm. of the same rainfall would increase wheat production by 4kg/ha only .

- The maximum importance of March and April rain for wheat production because this period is vital for the production noting that an increase of 1mm. of rainfall would increase production by about 10 kg/ha . Regarding barley it appears that these rains would have only a minor effect .

- The high importance of rainfall during March and April for wheat production compared to rainfall in previous period (February, December and January) because March and April represent a critical period in the wheat crop life and any changes in this rainfall would have a positive or negative effect on the level of production .

5.3 Effect of Varieties of Wheat and Barley:

The varieties of wheat and barley differ in their level of production under rainfed conditions noting that some of these varieties give high yield even under dry conditions .

Table (31) classifies the varieties according to their yield and their tolerance to drought .

TABLE 31:

Order / Crop	1	2	3	4
Wheat Variety	ACSAD 59	ACSAD 65	ACSAD 67	ACSAD 71
Barley Variety	ACSAD 60	ACSAD 176	ACSAD 68	

It appears that wheat variety (ACSAD 59) was more tolerant to drought compared to other wheat varieties and that wheat variety (ACSAD 71) was less tolerant to drought compared to other varieties . Regarding barley it appears that (ACSAD 60) was more tolerant to drought compared to other barley varieties and that ACSAD 68 was less tolerant to drought compared to other varieties .

Rain distribution affect wheat and barley production according to the varieties used in planting . Field studies shows the following results :

- In wet years wheat varieties (ACSAD 65 and ACSAD 71) outyielded other varieties . In year of less rainfall wheat varieties (ACSAD 59 and ACSAD 67) gave higher yield compared to other varieties .

- During March and April barley variety (ACSAD 176) was more tolerant to drought compared to other varieties while barley variety (ACSAD 68) was less tolerant to drought compared to other varieties .

This means that a decrease in the amount of rainfall during March

and April would have a negative result for barley variety (ACSAD 68) while it would have no important effect on barley variety (ACSAD 176) . Regarding February rains it appears that barley varieties (ACSAD 60, ACSAD 176 and ACSAD 68) would be equally affected by these rains . In general the amount of rainfall during February is considered as a factor in the increase or decrease of production according to rainfall trends during this month .

5.4 Effect of Temperature:

Temperature plays an important role in the cereal production regions due to the fact that appropriate temperature is vital for different stages of growth of plants .

The temperature which suits wheat and barley is between a minimum of 6°C and a maximum of 25-30°C . Any increase or decrease in this temperature during the first growth stages of plants would badly affect the crop .

5.5 Economic Factor:

The economic factor plays a vital role in the general situation of agricultural production . It helps improve the level of production through providing services and inputs for crops .

In general most of cereal growers receive incomes that are not sufficient for expenditure on agricultural operations needed to improve the level of crop production . These low incomes received by cereal growers are attributed to the pricing policy which take into consideration the costumers' interest and not that of the cereal growers . The low prices set for food and agricultural crops lead to a decline in the level of agricultural return

of these crops . Moreover, the loans provided to farmers are not sufficient for expenditure on all requirements for crop production . The total loans (cash and in kind)provided for plant production in 1982 amounted to about US$ 47.9 million , i.e. about an average of US$ 12.5 for each hectare of agricultural land (about AD 56.7) .

The low incomes received by farmers and the decline in loans provided for plant production contribute to the deterioration of the level of wheat and barley production . Therefore, it is necessary to reconsider the pricing policy and increase the level of loans for plant production in order to help improve agricultural production in general and wheat and barley production in particular .

5.6 Agricultural Holdings:

The size of agricultural holdings plays an important role in the increase or decrease of production in the unit area . Agricultural exploitation in the form of large investment units helps increase agricultural production at less costs and this is due to possibility of use of modern techniques .

The size of agricultural holdings of less than 10 hectares constituted about 27% of the total cropped area in Algeria in 1982 . These holdings included about 80% of the total agricultural holders in Algeria . About 50% of the total cereal area in Algeria is still under the private sector which is characterized by severe fragmentation of agricultural holdings and this situation hinders the development of production .

and the soil . The use of fertilizers should be at appropriate rates and dates in order to preserve soil fertility and improve the level of production in the unit area .

- Reconsideration of the crop rotations practised in irrigated lands and organization of these crop rotations in a way that allow the economic use of water resource and limit the waste in water which causes many problems for crop production . In the rainfed areas we recommend the eradication of fallow through the adoption of appropriate crop rotations . We recommend also the introduction of annual forage legumes into the crop rotation in the areas receiving low rainfall in order to improve productivity of cereals, conserve soil moisture and limit soil erosion .

- Generalization of improved cultural practices, particularly in the field of deep plowing and the use of drills in order to improve the level of production .

- Adoption of an integrated program for weed and pest control . Such a program would help improve the level of cereal production and limit the harm of weed and pests in crop fields .

- Consolidation of holdings in large units to allow the economic use of modern techniques and obtain high profits . It should be noted that the private sector in Algeria dominates more than 50% of the total cereal areas . These areas are severely fragmented into small holdings and this situation hinders the development of production . Statistics of 1982 indicate that about 27% of the total cropped areas are characterized by holdings of

less than 10 ha each . These holdings comprise about 80% of the total agricultural holders in Algeria .

- Reconsideration of the pricing and financing policies for cereal crops, increase of loans provided to farmers and linking prices with actual production costs . Such measures would help farmers to carry out the agricultural operations in a way that ensure high productivity .

- Drawing up an integrated program for agricultural extension to serve cereal growers in their fields and improve the relationship that exists between agricultural extension workers and farmers through the holding of training courses and seminars with the aim of encouraging the farmers to adopt improved practices . It is worth refferring here to the importance and role of the pilot fields which induce farmers to improve the level of their crop production .

- Drawing up an integrated program for early warning to benefit from environmental information in the agricultural planning prior to planting season .