Forecasting model of grain in Morocco .

FORECASTING MODEL OF GRAIN PRODUCTION IN RELATION TO WEATHER VARIABILITY IN MOROCCO

By

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INTRODUCTION

Production of Grains is the major food security problem, facing all Arab countries, Grains are produced in most of Arab countries under rain-fed extensive agri-cultural pattern. Morocco is a quite representive model for this pattern. The influence of varying weather conditions on crop yield is an obvious cause-and-effect relationship, with, but little possibility of circular reasoning. Many efforts were made to identify and measure these relationships. The principal weather condition in most of literatures and the present work is rainfall.

Data Used

Data of rainfall in mm. and number of rain days either yearly or monthly were collected for 5 years from

Monoufia J. Agric. Res., Vol. 2, Dec.1979

12 weather stations in Morocco along with corresponding annual grain yield per hectar in kentars. A thirty years averages of Monthly rainfall were also available. Observations were recorded for the period 1969/1970 up to 1973/1974.

Analysis & Emperical Results

Estimated average of annual grain yield per hectar for Morocco was about 10.5 kentars with a standard error ± 2.98 kentars. The coefficient of variability for average annual grain yield was about 28.5 percent. The annual grain yield per hectar ranged between 6.7 kentars and 14.4 kentars. The average annual rainfall for Morocco over five years and 12 regions was about 520 millimeters ± 90 millimeter and a coefficient of variability about 17.3%. The average annual number of rainy days was about 87 days ± 7.7 days and a coefficient of variability about 10%.

However, the variability in grain yield increases in poor-rain years as in 1972/1973, where the coefficient of variability reached about 50%. This reflects the differences in poor rain effect on different regions. The estimated coefficient of variability of annual grain yield per hectar between years within regions confirms this conclusions. It is at maximum for those regions of annual rainfall less than 350 millimeter, i.e. It ranges between 79.5% to 38% while it ranges between 12.5% to 4.7% for regions of average annual rainfall above 600 millimeter.

The dependant variable in the proposed forecasting model is the annual grain yield per hectar. Rain intensity as a major independent variable was expressed in two variables. They are annual rainfall in mm. and numbers of rainy days per year. However, highly correlation (Multicolinearity) between rainfall and number of rainy days was found. The calculated correlation coefficient was about .8295. Therefore one of both variables should be eliminated. An extensive study review by Sanderson (1954), of such work, in many different regions and countries emphasized that independant variables are detected by retaining only those out of the many examined which showed the highest correlation with the dependant variable. The correlation coefficient between annual grain yield and annual rain fall is about 0.3649, while the correlation coefficient between annual grain yield and number of rainy days in about 0.3283. This result shows that annual grain yield is of higher association with rain fall than with number of rainy days.

On the other hand, models (1-2) and (1-2) - Tables

(1) - emphasize the conclusion that number of rainy days must be eliminated keeping only rainfall as an independant variable.

However, the linear form lacks for best fitting conditions in terms of poor coefficient of determination. Before starting the statistical process, the conditions to be observed in fitting the model must be stated. For rainfall, the considerations quite similar to those discussed in (Ezekiel & Fox, 1959) for applied irrigation water. These considerations would lead to a curve with the following characteristics: (1) It should rise steeply at low rainfall rate, and then less and less sharply, until a maximum yield is reached, (2) it might show a decline after the single maximum yield is reached, either gradual or sharp, and (3) it would have only the single point of maximum yield. These are the conditions that would be applied in selecting function for fitting the curve.

The two regression forms (1-3) and (1-4) in table (1) show that the relation is not absolute linear, the function of best fit expressing the logical conditions mentioned above is the quadratic form - model (1-3). It increases the mean square due to regression, in comparison with both linear for (1-1) model - Table (1) and power form-model (1-4). The net effect of quadratic term is significant at probability level less than .01. This curvelinear regression form of grain yield on rainfall is supported by the results obtained by Misner, (1928). This earlier study prooved a curvlinear (quadratic) relationship between corn yield and rain fall for nine weather stations scattered through the corn belt in U.S.A. According to form (1-4) - Table (1) the optimum annual rainfall per gram production is about 700 millimeter. Therefore, the maximum annual grain yield is about 12 kentars per hectar.

Fisher (1924), studing wheat yields at Rothamstead (U.S.A.) pointed out that it really made little difference to the growth of a crop whether a given rain occurred on april 30 May 1. The resulting smooth curve showed that the maximum effect of rainfall on yield was in autumn and in spring. With rainfall distribution, the only weather variable considered, correlations ranged from 0.32 to 0.63. Also Misner, (1928) represented the rainfall by the average of rainfall during June, July, and August per year for nine weather stations scattered though the corn belt.

Waugh and associates (1929) confirmed the use of monthly rainfall as an independant variable in their works on potato-yield problem. More elaborate investigations, experimental and statistical, have shown that the effect of rainfall vary at different times of the season, and especially at certain critical times in the growth of the plant, such as at lasseling.

The present study showed that the correlation coefficient between average rainfall and number of rainy days on monthly bases was also high as an annual basis. On monthly intervals it was about 0.9002. Therefore, the number of days as an independendant variable was excluded from the proposed forecasting model correlation between the monthly average rain fall and annual grain yield were estimated to show the highest effective monthly rain fall on yield. The three spring months, i.e. March, April and May showed of the highest correlation coefficients between rainfall in m.m and annual grain yield. These coefficient were 0.8525 for march, 0.5471 for April and 0.6816 for May.

The estimated forms in Table (2) shows that March is the most critical month for grain production in Morocco. The elasticity of production estimated for March is about

Forecasting model of grain in Morocco.

0.4537, i.e. an increase by 1 percent in March rainfall above the average leads to an increase of about 0.4537 percent in grain yield per hectar above the average of the country - form (2-1) - Table (2).

The other conclusion is that April and May are substitutes for March, i.e. if the rain fall in March is not high enough, the grain crops may benefit high rainfall in both April and May together, but not each one separately. However, April and May joint effect is not as much as March effect the total elasticity of production of both months is only 0.1231, i.e. only 0.27% of that of March.

The forcasting model include all three months shows the actual response. From model (2-7) - it is clear that April rainfall in a substitute for March rainfall. May rainfall supports March rainfall in raising the average grain yield. The net elasticicity of production is about 0.61, i.e. an increase of 1% in average rainfall of spring rainfall leads to an increase of about 0.61% in annual grain yield per hectar in Morocco.

It should be mentioned that, the total rainfall in spring (March, April and May) is about 26.5% of average annual total rainfall of Morocco (the average of 30 years). March rainfall is about 46% of the average spring rainfall, while April rainfall is about 34% of the average spring rainfall. The rest i.e. about 20 percent comes in May - Table (3). On the other hand March rainfall on the average of 30 years is about 146% of the agreggate monthly average of 12 months. The average of 30 years. April rainfall is much closer to the agreggate monthly average. It represents about 109 percent of such agreggate average. May rainfall is below the agreggate average by about 38 percent - Table (3).

SUMMARY AND CONCLUSIONS

This study was made to investigate the effect of weather conditions (rainfall) on grain production in Morocco. The data were collected for the period 1969/70 - 1973/74. It was found that variability in grain yield increased in poor-rain years (1972/1973), where the C.V. amounted to 50% and in regions of annual rainfall less than 350 m.m. where the C.V. ranged between

Forecasting model of grain in Morocco.

79.5% and 36.0%. High correlation was found between the number of rain days and rainfall in m.m. Therefore, the later was used as independent variable in the model. The quadratic form was the one that best fitted the logical relationship between grain yield and annual rainfall amounted to 700 m.m. correlation coefficients between grain yield and monthly rainfall were high for spring (0.8525 for March, 0.5471 for April, and 0.6816 for May), with March as the critical month for grain production where the elasticity of production amounted to 0.4537. April and May rainfall was substitute for March, but their joint effect is not as much as that of March. Rainfall in spring season indicated an elasticity of production amounting to 0.61 with this rainfall representing 26.5% of the annual rainfall.

Monoufia J. Agic. Res., Vol. 2.Dec.1979

Table (1): Estimated forecasting model for rainfall effect on grain yield in Morocco.

Equation No.	Estimated Model	S_{b_1}	S_{b_2}	R^2
1-1	$\hat{G}_t = 7.9635+0.005044\ M_t$	0.001817	--	0.1332
1-2	$\hat{G}_t = 7.4085+0.0040698 M_t$ $+0.013537\ D_t$	0.003205	.03722	0.1355
1-3	$\hat{G}_t = 3.41820+0.023815 M_t$ $-0.000017 M^2$	0.006715	.00006	0.2602
1-4	$\hat{G}_t = 0.4620\ M_t^{.4929}$	0.2014	--	0.2232

Where:

G_t = denotes estimated quantity in kentars of annual grain yield per hectar, in year t.

D_t = Is the annual average of numbers of rainy days in the year t.

M_t = Is the average of annual rain fall in millimeter in the year t.

S_{b_1} = Designates the estimated standard error of the corresponding regression coefficient.

R^2 = Is the determination coefficient.

Testing the null hypothesis that B of the population equals Zero at P 0.05 showed that the number of rainy days is not statistically different from zero.

Forecasting model of grain in Morocco.

R^2 as a test for fitting a curve showed that the quadratic form is the best fitted one out of several forms estimated including semi-log function, inverse function, double log inverse function and finally a power curve. All but the power one are not presented in Table (1) because their coefficients of determination were either less or equal to that of the power curve presented by equation 1-4.

Table (2): Estimated forcasting rainfall model for grain yield in Morocco.

Month	Equation No.	Estimated model	S_{b_1}	S_{b_2}	S_{b_3}	R^2
March	2-1	$\hat{G}_t = 1.4481\, M_3^{.4537}$	0.0566	--	--	0.7063
April	2-2	$\hat{G}_t = 7.4905\, M_4^{.0844}$	0.0876	--	--	0.2369
May	2-3	$\hat{G}_t = 8.7279\, M_5^{.0571}$	0.0743	--	--	0.1662
March & April	2-4	$\hat{G}_t = 1.4389\, M_3^{.4572}\, M_4^{-.0022}$	0.2659	0.1519	--	0.7050
April & May	2-5	$\hat{G}_t = 6.6782\, M_4^{.0752}\, M_5^{.0479}$	0.0117	0.0095	---	0.9911
March & April	2-5	$\hat{G}_t = 1.5200\, M_3^{.4256}\, M_5^{.0235}$	0.2081	0.543	--	0.7300
March & April & May	2-7	$G_t = .7561\, M_3^{.5868}\, M_4^{-.0011}\, M_5^{.0235}$	0.0108	0.0010	0.0005	0.9778

Where: $\hat{G}_t$: denotes estimated quantity of annual grain yield in kentars per hectar.

M_3, M_4 and M_5 are March, April and May rainfall in millimeter respectively.

S_{b_i} and R^2 have the same meaning as mentioned below table (1)

Forecasting model of grain in Morocco.

Table (3): Relative share of seasonal rainfall in Morocco in total annual rainfall as an average of 30 years.

Season	Rainfall in m.m. (average of 30 years)	percentage
Autumn	125.9	25.73
Winter	217.7	44.48
Spring	129.7	26.50
Summer	16.1	3.29
All year	489.4	100.00
March	59.3	145.52
April	44.6	109.15
May	25.4	[illegible]
12 months average	40.75	[illegible]0.00

Monoufia J. Agric. Res., Vol. 2. Dec.1979

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Forecasting model of grain in Morocco.

الملخص العربي

دراسة تأثير العوامل الجوية على أنتاج الحبوب بالمملكة المغربية

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موجز

اجرى هذا البحث لدراسة تأثير العوامل الجوية (المطر) على انتاج الحبوب بالمملكة المغربية باستخدام بيانات سنوية وشهرية خلال عشر سنوات من ١٩٦٩/١٩٧٠ الى ١٩٧٣/١٩٧٤ على مستوى ١٢ منطقة. وقد اوضحت الدراسة ان الاختلاف فـي انتاجية الهكتار من الحبوب ارتفع في السنوات الفقيرة في محصولها (١٩٧٢/١٩٧٣) حيث بلغ معامل الاختلاف ٥٠% وذلك في المناطق التي يقل فيها المعدل السنوي للامطار عن ٣٥٠ ملليمتر والتي تراوح فيها معامل الاختلاف بين ٢٩,٠% الى ٣٨,٠% وقد تبين ان هناك ارتباط قوي بين عدد الايام الممطرة وكمية المطر سواء على مستوى الشهور او الاعوام وبذلك تم استخدام كمية المطر وحدها كمتغير مستقل في النماذج التي تم حسابها بهذه الدراسة. وكانت الدالة التربيعية هي افضل النماذج التي توضح العلاقة بين انتاجية الهكتار من الحبوب وكمية المطر السنوية والتي تعطي اقصى انتاجية تبلغ ١٢ قنطار للهكتار عندما يبلغ معدل الامطار ٤٠٠ ملليمتر سنويا. وبدراسة ارتباط بين الانتاجية وكمية المطر في شهور الربيع تبين ان هناك ارتباط قوي يبلغ ٠,٨٥٢٥ في مارس و ٠,٥٤٧١ في ابريل و ٠,٦١٦٥ في مايو وكانت امطار مارس اكثر حرجا بالنسبة لانتاجية الحبوب حيث بلغت المرونة الانتاجية ٠,٤٣٧ وتعتبر امطار ابريل ومايو بديلة لامطار مارس. ولو ان مرونتها الانتاجية اقل من تأثير مارس وتمثل امطار شهور الربيع ٢٦,٥% من المعدل السنوي الا ان مرونتها الانتاجية بلغت ٠,٦١ ...
