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The economic effect of maize yellow varieties on total factors productivity in Beheira Governorate

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Abstract: By studying the economic effect of the maize Single Hybrid varieties (3444, 3084, 2055) under study on total factor productivity in Beheira Governorate, the research aims to compare the productive features of these varieties by studying the productive indicators and economic changes in total factor productivity, the rate of technological change, and the rate of technological growth, in order to know which variety is the best that achieves a positive effect on technological change and total factor productivity and contributes to bridging the production gap with high economic efficiency. A study of the future situation of the area, productivity, and production of maize yellow in Egypt and the Beheira Governorate during the period under study revealed that the productivity per feddan in Egypt is expected to decrease from 3.104 tons/fed. In 2025 to about 3.053 tons/fed. In 2029, this resulted in a decrease in the quantity of the crop produced from 2403.7 thousand tons in 2025 to about 2345.5 thousand tons in 2029. Therefore, the decrease in the quantity of the crop produced in Egypt is due to the decrease in the productivity per feddan of maize yellow. Therefore, it is expected that the quantity and value of maize imports will increase from 10.76 million tons, 88.98 billion EGP in 2024 to about 12.36 million tons, 166 billion EGP in 2029. This is due to the decrease in the quantity of the crop produced during the period 2025-2029 to bridge the gap between production and consumption in Egypt. As for the Beheira Governorate, the area of maize yellow crop is expected to increase from 151.2 thousand feddans in 2025 to about 192.8 thousand feddans in 2029, which will result in an increase in the quantity of crop production from 509.5 thousand tons in 2025 to about 648.3 thousand tons in 2029. Therefore, this increase in the quantity of maize production in Beheira is due to the increase in area and not productivity. A study of production and economic indicators revealed that the maize Single Hybrid variety 3444 in Beheira Governorate outperformed the maize Single Hybrid varieties 3084 and 2055 in productivity per feddan. This resulted in a higher profit margin per ton of 5641 Egyptian EGP. Therefore, this variety is characterized by high productivity in utilizing production inputs, yielding the best return on investment of approximately 0.59 EGP and the best profit margin per ton, reaching 37.1%, when farmers expand their cultivation in the research area of Beheira Governorate. Based on the results of the total factor productivity analysis, it was shown that the maize Single Hybrid variety 3444 has economic importance and a positive impact on technological change of approximately 15.1% and 47.8%, respectively, compared to the maize Single Hybrid varieties 3084 and 2055. Furthermore, it led to an improvement in total factor productivity of approximately 15.1% and 44.8%, respectively, compared to the other varieties. With the two varieties mentioned above and with the continued cultivation of the single maize yellow variety 3444 in the future, a proposal or scenario was developed which, if implemented, would lead to an increase in the production of maize yellow in Beheira Governorate and Egypt and a reduction in the quantity of maize imports, as follows: **1)** If maize farmers in Beheira Governorate expand their cultivation of the maize Single Hybrid variety 3444 in place of the maize Single Hybrid varieties 3084 and 2055, this will result in a 4.53% increase in the governorate's total maize production, which is expected to reach approximately 485.8 thousand tons during the 2024 production season. 2) A study of the effect of cultivating the maize Single Hybrid variety 3444 in place of the maize Single Hybrid varieties 3084 and 2055 on the average quantity of maize yellow imports, which amounted to 7.25 million tons during the period 2010-2023 across Egypt, will lead to an increase in the average production quantity of approximately 17.8%. This will result in a decrease in the quantity of imports of the crop of approximately 5.3%, leading to a reduction in the cost of importing maize yellow by approximately 5.3% compared to the average for the aforementioned period. **The research recommends the following: 1)** Higher-productivity maize yellow varieties, especially the maize Single Hybrid variety 3444, should be cultivated throughout Beheira Governorate area in place of the lower-productivity varieties to increase production and farmers' net income. 2) The Ministry of Agriculture and Land Reclamation and its affiliated research centers should expand their efforts to develop Higher- productivity varieties of maize yellow, in line with the research findings. 3) The agricultural extension service and research centers should play a more active role in persuading farmers to adopt modern

production methods by using the highest productive maize yellow varieties that have economic importance, a positive impact on technological change, and also lead to improvements in the total factors' productivity.

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Keywords: Yellow maize varieties; total factor productivity; technological change; technological growth rate.

Introduction:

Egypt is expanding the cultivation of maize yellow by developing improved varieties with high productivity and disease resistance, in addition to recommending the best agricultural practices increasing the productivity per acre. However, the quantities produced are still insufficient to meet the growing demand, forcing the country to import large quantities to bridge the consumption gap, estimated at about 7.3 million tons during the period (2010-2023) and valued at 27.5 billion pounds, which constitutes a burden on the Egyptian trade balance, according to the data contained in the bulletin of foreign trade statistics for agricultural exports and imports.

Maize is used in bread making by mixing it with wheat and fenugreek, and in feeding livestock and poultry, and for many purposes, including food, chemicals, and industry, most importantly starch, honey, olives, glucose, alcohol, and some medicinal drugs are extracted. The grains are eaten green, and the plants resulting from the breaking and leafing processes are given as green fodder to livestock in the summer. Firewood is also used as fuel and in the paper industry. Maize may be grown in Egypt as fodder for livestock in the summer, and in this case it is called "Tarawa". Currently, corn is widely used in animal feed in the form of silage. Oil is extracted from the corn germ, which makes up about 11% of the corn kernel, at a rate of about 35%. The percentage of oil in the kernel represents about 4% oil.

Research problem:

The research problem revolves around the inadequacy of maize yellow production in Egypt to meet consumer needs, especially in the Beheira Governorate. Despite the state's efforts to increase productivity by introducing new varieties and encouraging farmers to cultivate varieties according to their productive and economic merit, the research aims to compare the productive features of these varieties by studying the productive indicators and economic changes in total factors productivity, the rate of technological change, and the rate of technological growth, in order to identify the best variety that achieves the highest positive impact on technological change and total factors productivity, which means that it contributes to bridging the consumption gap with high economic efficiency.

Research objective:

The research objective was primarily to:

1. The current and future status of the total area and production of maize yellow in Egypt and Beheira Governorate during the period 2010-2024.
2. The current and future status of the quantity and value of imports of maize yellow crop in Egypt during the period 2010-2023.
3. Analysis of the variance between the production cost items and the economic indicators for the maize yellow varieties under study in the research sample in Beheira Governorate for the summer production season of 2024.
4. Measuring the effect of technological change in yellow maize varieties on the total factors productivity of the research sample in Beheira Governorate for the summer production season of 2024.
5. The effect of replacing higher-productivity maize yellow varieties with lower-productivity varieties on the total maize yellow production in Egypt and the research area.

Materials and methods:

The research relies on the quantitative approach, using econometric analysis, which includes applying mathematical models such as growth equations and exponential smoothing models to forecast some economic variables, including the area, production, and productivity of maize yellow crop in Egypt and Beheira Governorate during the period 2010-2024. It also measures productivity indicators and economic changes in total factors productivity, the rate of technological change, and the rate of technological growth, using the Malmquist index to study the productivity of three varieties of the maize yellow Single Hybrid variety (3444, 3084, and 2055) in Beheira Governorate.

The research sample:

1. **Selection of research sample centers for the maize yellow crop in Beheira Governorate**.

Table1 shows that the research sample centers were selected based on the relative importance of the

area cultivated with maize, as follows: Koum Hamada Center ranked first in maize yellow cultivation in Beheira Governorate, with an area of 20745 feddans, representing approximately 12.38% of the total maize yellow area in Beheira, Kafr El Dawwar Center comes in second place with an area of 20729 feddans, which represents about 12.37% of the total area of maize yellow in the governorate, then Damanhur Center in third place with an area of 19950 feddans, which represents about 11.9% of the total area of maize yellow in Beheira for the production season 2024. These centers together represent about 36.65% of the total area of maize yellow in Beheira Governorate for this season.

Table1: Total area of maize yellow crop and its most important varieties of Beheira Governorate for the production season 2024.

Area* / The Center	Area (feddan)	%	The maize yellow Single Hybrid Varieties					
			3444	%	3084	%	2055	%
Koum Hamada	20745	12.38	7081	14.6	5088	18.0	0.00	0.00
Kafr El Dawwar	20729	12.37	3687	7.60	2843	10.0	558	3.90
Damanhur	19950	11.90	3318	6.90	3349	11.8	3125	21.7
Itay El Barud	19034	11.35	4363	9.00	2488	8.80	2675	18.6
El Delengat	16898	10.08	5734	11.9	2844	10.0	300	2.00
Abu El Matamir	16096	9.600	3919	8.00	367	1.30	3500	24.3
Abu Hummus	13034	7.780	2979	6.20	980	3.50	760	5.30
Shubra Khit	11598	6.920	6074	12.6	5024	17.7	201	1.40
Hosh Essa	8617	5.140	4174	8.60	1971	7.00	0.00	0.00
Rahmaniyya	7484	4.460	2536	5.20	604	2.10	1785	12.4
Wadi El Natrun	4146	2.470	1519	3.10	1625	5.70	0.00	0.00
El-Mahmoudia	4046	2.410	1591	3.30	610	2.20	411	2.80
Gianaclis	3700	2.210	1000	2.10	350	1.20	1100	7.60
Edku	1324	0.790	245	0.50	200	0.70	0.00	0.00
Rashid	232	0.140	182	0.40	0	0.00	0.00	0.00
Total	**167633**	**100.0**	**48402**	**100**	**28343**	**100**	**14415**	**100**
%	**100**	**0.00**	**28.9**	**0.00**	**16.9**	**0.0**	**8.6**	**0.00**

*Area = feddan = 4200 m^2

Source: Compiled and calculated from: Ministry of Agriculture and Land Reclamation, the Directorate of Agriculture in Beheira, statistics Department, and unpublished data.

2. Selecting the varieties of maize yellow under study in Beheira Governorate according to the relative importance of the variety area.

By reviewing the data contained in Table1, the varieties of maize under study were selected according to the relative importance of their area out of the total area of maize varieties at the level of Beheira Governorate, the area planted with the Single Hybrid variety 3444 reached about 48402 feddans, representing about 28.9% of the total area of the crop at the governorate level, then the Single Hybrid variety 3084 with an area of about 28343 feddans, representing 16.9% of the total area of the crop at the level of Beheira, and finally the area planted with the Single Hybrid variety 2055 reached about 14415 feddans, representing about 8.6% of the total area of the varieties at the level of Beheira Governorate. These varieties under study together represent about 54.4% of the total area of maize yellow for this season.

3. Selecting the varieties of maize yellow under study within the centers represented in the sample according to the relative importance of the variety area.

Table 1 shows that the maize yellow the Single Hybrid 3444 was selected in Koum Hamada and Kafr El Dawwar centers, with an area of 10768 feddans, representing about 76.4% of the total area of the variety, which is 14086 feddans at the level of the three centers representing the research sample, and representing about 22.2% of the total area of this variety in the Beheira Governorate, then the maize yellow the Single Hybrid variety 3084 in Koum Hamada and Damanhur with an area of about 8437 feddans, representing about 74.8% of the total area of this variety, which is 11280 feddans at the level of the three above-mentioned centers, and representing 29.8% of the total area of the Single Hybrid variety 3084 at the level of Beheira. Finally the Single Hybrid variety 2055 in Damanhour Center, has an area of about 3125 feddans, represents about 84.8% of its total area of about 3683 feddans at the level of (Koum Hamada and Kafr El Dawwar and Damanhur) Centers and

represents about 21.7% of its total area at the level of the governorate.

4. The selection of agricultural associations within the centers represented in the research sample for the maize yellow varieties under study, according to the relative importance of the number of farmers.

Table 2 shows the selection of agricultural associations for the maize yellow Single Hybrid variety 3444, 3084, 2055 in Beheira Governorate according to the relative importance of the number of farmers of those varieties within the agricultural associations as follows:-

- For the Single hybrid variety **3444**, the selection of The Al-Bureijat Association in Koum Hamada Center was chosen, representing about 6.39% of the total number of farmers of this variety, which is about 6264 farmers at the level of the center, and the Kom Ushu Association in Kafr El Dawwar Center, representing about 23.85% of the total number of farmers of this variety, which is about 2935 farmers at the level of the center. Therefore, the number of farmers of the aforementioned variety at the level of the two centers reached about 1100 farmers.

Table 2: Number of farmers of the most important varieties of maize yellow at the level of agricultural associations in selected the centers in Beheira Governorate for the production season 2024.

The Center	the association	Number of maize variety farmers					
		3444	%	3084	%	2055	%
Koum Hamada	Al-Bureijat	400	6.39	388	7.70	-	-
	Waked			360	7.14		
Total number of farmers for the variety at the center		**6264**		**5039**		-	-
Kafr El Dawwar	Kom Ushu	700	23.85	-	-	-	-
Total number of farmers for the variety at the center		**2935**		-	-	-	-
Damanhur	Al-Bayda	-	-	171	5.50	202	7.90
	Qartasa	-	-	-	-	191	7.48
	Hafs	-	-	181	5.82	182	7.12
	Ezbet Qabil	-	-	-	-	176	6.89
	Basatra	-	-	-	-	175	6.85
	Qaraqis	-	-	-	-	174	6.81
Total number of farmers for the variety at the center		-	-	**3111**		**2554**	

Source: Ministry of Agriculture and Land Reclamation, Beheira Agriculture Directorate, Agricultural Administration at (Koum Hamada, Kafr El Dawwar and Damanhur), Statistics Department, Unpublished Data.

- As for the single hybrid variety **3084**, the Al-Bureijat and Waked Associations in Koum Hamada Center were selected, representing about 7.7% and 7.14% respectively of the total number of farmers of this variety, which is about 5039 farmers at the level of the center, and the Al-Bayda and Hafs Associations in Damanhur Center, representing 5.5% and 5.82% respectively of the total number of farmers of this variety, which is about 3111 farmers at the level of the center. Therefore, the number of farmers of the single hybrid variety 3084 at the level of the two centers reached about 1100 farmers.
- Finally, the Single hybrid variety **2055** was selected from the associations of (Al-Bayda, Qartasa, Hafs, Ezbet Qabil, Basatra, and Qaraqis) in Damanhour Center, representing approximately 7.90%, 7.48%, 7.12%, 6.89%, 6.85% and 6.81% respectively out of the total number of farmers of this variety, which is approximately 2554 farmers at the level of the center. Therefore, the number of farmers of the single hybrid variety 2055 at the level of the center reached about 1100 farmers.

5. Selecting the sample size for the most important maize yellow varieties of Beheira Governorate for the production season 2024.

From the previous narrative of selecting the research sample, the number of farmers of the maize yellow varieties of the Beheira Governorate at the level of the agricultural associations represented in the research sample amounted to about 1100 farmers for each variety separately, and taking 5% of the number of farmers who cultivate maize yellow the Single variety 3444, 3084, 2055. Therefore, the size of the research sample for the varieties under study amounted to about 165 farmers, with about 55 farmers for each variety separately. It is noted that the number of sample observations was chosen randomly within the boundaries of each agricultural association, and therefore the research sample is called a multi-stage random cluster sample.

Data sources:

The research relied on two main sources for data collection: the first source: secondary data published and unpublished and issued by the Economic Affairs Sector and the Agriculture Directorate in Beheira Governorate. The second source: primary data collected through a questionnaire on the productivity and costs of the most important of the maize yellow varieties, namely the Single Hybrid variety (3444, 3084, 2055) from the Centers (Koum Hamada and Kafr El Dawwar and Damanhur) during the production season 2024 in Beheira Governorate.

Results and Discussion:

First: The current and future status of the total area and production of maize yellow in Egypt and Beheira Governorate during the period 2010–2024:

1. **The current status of the area, production, and productivity of maize yellow in Egypt and Beheira Governorate during the study period 2010–2024:**

The data in Table 3 show an increase in the area cultivated with maize yellow in Egypt and Beheira Governorate during the period 2010-2024, from 379.2 and 74.8 thousand feddan in 2010 to approximately 756.8 and 140.8 thousand feddan respectively in 2024, representing an increase of approximately 99.6% and 88.2% respectively. The productivity per feddan of the crop in Egypt and Beheira also increased during the study period from 2.853 and 3.049 tons/feddan in 2010 to approximately 3.112 and 3.373 tons/feddan respectively, in 2024, representing an increase of approximately 9.1% and 10.6% respectively. Consequently, the total maize production increased from 1,081.9 and 228.1 thousand tons in 2010 to approximately 2355.2 and 474.9 thousand tons in 2024, with an increase of approximately 117.7% and 108.2% respectively.

Table3: The current status of the area, production, and productivity of maize yellow in Egypt and Beheira Governorate during the study period 2010–2024:

The Years	Egypt			Beheira Governorate		
	Area[1] Thousand feddan	**Productivity**[2] Ton/fed.	**Production**[3] Thousand ton	**Area**[1] Thousand feddan	**Productivity**[2] Ton/fed.	**Production**[3] Thousand ton
2010	379.20	1081.9	1081.9	74.80	3.049	228.1
2011	340.80	1041.5	1041.5	39.00	3.012	117.5
2012	388.20	1198.8	1198.8	61.30	3.348	205.2
2013	513.00	1592.9	1592.9	78.20	3.169	247.8
2014	567.00	1784.9	1784.9	100.9	3.342	337.2
2015	591.10	1886.2	1886.2	128.0	3.221	412.3
2016	742.40	2342.3	2342.3	147.1	3.254	478.7
2017	915.90	2882.3	2882.3	153.7	3.488	536.1
2018	1003.3	3149.4	3149.4	132.9	3.287	436.8
2019	917.30	2906.0	2906	112.2	3.495	392.1
2020	805.70	2563.7	2563.7	95.50	3.475	331.9
2021	888.10	2837.5	2837.5	87.10	3.623	315.6
2022	649.10	2040.1	2040.1	119.4	3.533	421.8
2023	853.10	2702.6	2702.6	151.7	3.513	532.9
2024	756.80	2355.2	2355.2	140.8	3.373	474.9
average	**687.40**	**2157.7**	**2157.7**	**108.2**	**3.345**	**364.6**
growth rate	**6.20%**	**0.40%**	**6.60%**	**5.60%**	**1.00%**	**6.60%**
Rate of increase*	**42.6**	**0.0125**	**142.4**	**6.1**	**0.0335**	**24.1**

(*) It refers the amount of increase in area or output = (growth rate/100) x series average for area or output during the period.

1. It refers to the total area of maize yellow for the (summer + Nile) season during the study period.
2. It refers to the weighted average productivity of the maize yellow crop for the (summer + Nile) season during the study period.
3. It refers to the total production of maize yellow for the (summer + Nile) season during the study period.

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economics, Agricultural Statistics Bulletin, various issues.

The results of the growth rate estimation in Table No. (3, 4) for the area of maize in Egypt and Beheira Governorate showed that the increase in its area was estimated at about 42.6 and 6.1 thousand feddans, with an annual growth rate of 6.2% and 5.6% of the average crop area of 687.4 and 108.2 thousand feddans respectively during the period under study. The increase in productivity per feddan of maize yellow in Egypt and Beheira Governorate was estimated at about 0.0125 and 0.0335 Ton/feddan, with an annual growth rate of 0.4% and 1.0% respectively, during the period 2010-2024. This resulted in an increase in the production of the maize yellow crop during the same period by about 142.4 and 24.1 thousand tons, with an annual increase rate of 6.6% and 6.6% of the average crop production quantity of about 2157.7 and 364.6 thousand tons respectively.

Table 4: Results of estimating growth equations for the area, production and productivity of maize crop in Egypt and Beheira Governorate during the study period.

	The items	The equation	Average period	growth rate	t_{B_1}	F	R^2
Egypt	**Area**	$\hat{Y} = e^{12.9+0.062X}$	687.4	6.2**	4.6**	21.2**	0.62
	Productivity	$\hat{Y} = e^{1.11+0.004X}$	3.123	0.4*	2.7*	7.30*	0.36
	Production	$\hat{Y} = e^{14+0.066X}$	2157.7	6.6**	4.6**	21.2**	0.62
Beheira	**Area**	$\hat{Y} = e^{11.1+0.056X}$	108.2	5.6**	3.1**	9.61**	0.43
	Productivity	$\hat{Y} = e^{1.13+0.01X}$	3.345	1.0**	4.7**	22.1**	0.63
	Production	$\hat{Y} = e^{12.2+0.066X}$	364.6	6.6**	3.6**	13.0**	0.50

** Significance level: 0.01

Source: Collected and calculated from the data contained in Table No. (3).

2. Forecasting the area, production, and productivity of the yellow maize crop in Egypt and Beheira Governorate during the study period 2010-2024:

It was shown through the application of a number of statistical measures used in choosing the appropriate forecasting model, namely the sum of squared residuals and the root mean squared error, the best models for analyzing this data for the area, production and productivity of yellow maize in Egypt and Beheira, as shown in Table 5 were the two-parameter model of the Holt-Winter model, due to the achievement of coefficients that give the lowest root mean squared error and the sum of squared residuals.

Table 5: Forecasting the area, production, and productivity of yellow maize crop in Egypt and Beheira Governorate during the study period 2010-2024.

The Years	Egypt			Beheira Governorate		
	Area Thousand feddan	**Productivity** Ton/fed.	**Production** Thousand ton	**Area** Thousand feddan	**Productivity** Ton/fed.	**Production** Thousand ton
2025	786.0	3.104	2403.7	151.2	3.569	509.5
2026	797.1	3.091	2389.1	161.6	3.564	544.2
2027	808.3	3.079	2374.6	172.0	3.56	578.9
2028	819.4	3.066	2360.0	182.4	3.556	613.6
2029	830.6	3.053	2345.5	192.8	3.551	648.3

Source: Collected and calculated from the data contained in Table No. (3).

Estimating the forecast values using the Holt-Winter model for the area of yellow maize crop in Egypt, Table 5 shows that the crop area in Egypt is expected to increase from 786 thousand feddans in 2025 to about 830.6 thousand feddans in 2029. In contrast, the productivity per feddan is expected to decrease at the level of Egypt from 3.104 tons/feddan in 2025 to about 3.053 tons/feddan in 2029, this results in a decrease in the quantity of yellow maize production in Egypt from 2403.7 thousand tons in

2025 to about 2345.5 thousand tons in 2029. Therefore, the decrease in production at the level of Egypt is due to the decrease in the productivity per feddan of yellow maize.

As for the Beheira Governorate, the area of maize yellow crop is expected to increase from 151.2 thousand feddans in 2025 to about 192.8 thousand feddans in 2029, which will result in an increase in the production of the crop in Beheira from 509.5 thousand tons in 2025 to about 648.3 thousand tons in 2029, while the productivity feddan is expected to decrease from 3.569 tons/feddan in 2025 to about 3.551 tons/feddan in 2029. Therefore, the increase in the production of the crop in Beheira is due to the increase in area and not productivity.

Second: The current and future status of the quantity and value of imports of maize yellow in Egypt during the period 2010–2023:

1. **The current status of the quantity and value of imports of maize yellow in Egypt during the study period 2010–2023:**

The data in Table 6 indicate an increase in maize yellow imports in Egypt during the period 2010-2023 from 4.84 million tons in 2010 to about 7.22 million tons in 2023, an increase of about 49%. This resulted in an increase in the value of maize yellow imports from 6.94 billion pounds in 2010 to about 74.4 billion pounds in 2023, an increase of about 971.5%. This is due to the increase in the exchange rate in the recent period.

Estimating the growth rate in Table 6, 7 for both the quantity and value of imports of maize yellow in Egypt, the increase in the quantity and value of imports was estimated at about 42.8 million tons, 4.31 billion pounds, with an annual growth rate of 5.9%, 15.7%, from the average quantity and value of imports of about 7.25 million tons, 27.48 billion pounds respectively during the study period.

Table 6: The current status of the quantity and value of imports of maize yellow in Egypt during the study period 2010–2023:

The Years	Quantity of imports	Value of imports
	million tons	billion pounds
2010	4.840	6.940
2011	6.860	12.57
2012	3.130	12.12
2013	5.740	13.37
2014	4.330	14.00
2015	6.780	13.49
2016	6.040	18.40
2017	8.700	30.52
2018	8.410	27.77
2019	12.81	31.07
2020	9.310	31.48
2021	8.860	44.31
2022	8.500	54.31
2023	7.220	74.40
average	**7.250**	**27.48**
growth rate	**5.9%**	**15.7%**
Rate of increase*	**42.8**	**4.31**

Source: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economics, Bulletin of Foreign Trade Statistics for Agricultural Exports and Imports, various issues.

Table 7: Results of estimating growth equations for the quantity and value of imports of maize yellow crop in Egypt during the study period.

The items	The equation	Average period	growth rate	t_{B_1}	F	R^2
Quantity (million tons**)**	$\hat{Y} = e^{1.5+0.059X}$	7.25	5.90**	3.20**	10.24**	0.46
Value (billion pounds**)**	$\hat{Y} = e^{1.9+0.157X}$	27.48	15.7**	14.0**	196**	0.94

** Significance level: 0.01

Source: Collected and calculated from the data contained in Table No. (6).

2. **Forecasting of the quantity and value of imports of maize yellow in Egypt during the study period 2010–2023:**

It became clear through the application of a number of statistical measures used in choosing the appropriate model for prediction that the best models for analyzing the quantity and value of maize yellow imports in Egypt in Table 8 are the Halt's two-parameters Methods due to reaching coefficients that give the lowest square root of the mean squared error and the sum of the squared residuals.

Estimating the forecast values using the Holt-Winter model for the quantity and value of maize yellow imports in Egypt, Table 8 shows that the quantity and value of maize imports are expected to increase from 10.76 million tons, 88.98 billion pounds in 2024 to about 12.36 million tons, 166 billion pounds in 2029, this is because, according to the estimated

forecast values for maize yellow production in Egypt, the production of the crop is expected to decrease during the period 2024-2029.

Third: Analysis of the variance between production costs and economic indicators for maize yellow varieties of the research sample in Beheira Governorate for the summer production season of 2024.

The results of the analysis of variance in Table 9 showed significant differences between each of the variable cost items (agricultural labor, automated labor, seeds, manure the fertilizer units, nitrogen the fertilizer units, phosphate the fertilizer units, potassium the fertilizer units and pesticides) and the total costs items, the main and secondary output, total revenue, net return, relative profitability (net return / variable costs) x 100, return on invested (net return / total costs), profit margin ratio (net return / total return) x 100, and profitability per ton (net return / feddan productivity) for the maize yellow varieties under study in Beheira Governorate.

Analysis of production costs and economic indicators for the maize yellow varieties of Beheira Governorate, in the research sample for the summer production season of 2024, as follows:

Agricultural labor: The data in Table 9 shows that the cost of agricultural labor for farmers of the maize yellow Single Hybrid variety (3444, 3084, 2055) in Beheira Governorate, amounted to approximately (5580, 6270, 7000) EGP/fed., representing 16.7%, 17.3%, 18.4%, respectively, of the total costs of the crop.

Table8: Forecasting the quantity and value of maize yellow imports in Egypt during the study period 2010-2023:

The Years	Quantity of imports million tons	Value of imports billion pounds
2024	10.76	88.980
2025	11.08	104.00
2026	11.40	120.00
2027	11.72	135.00
2028	12.04	151.00
2029	12.36	166.00

Source: Collected and calculated from the data contained in Table No. (6).

Table 9: Analysis of the variance between production costs and economic indicators for maize yellow varieties of Beheira Governorate for the summer production season 2024.

Inputs	Unit	The maize yellow Single Hybrid Varieties									
		3444			3084			2055			
		quantity	value	%	quantity	value	%	quantity	value	%	F
Variable costs:	-	-	-	-	-	-	-	-	-	-	-
Agricultural labor	Lab. /Fed.	31	5580	16.7	33	6270	17.3	35	7000	18.4	87**
Automated labor	Hour/Fed.	28	4200	12.6	30	4950	13.7	32	5440	14.3	62**
Seeds	KG/Fed.	9	3600	10.8	10	3701	10.2	12	3300	8.67	140**
manure fertilizer	M^2/Fed.	12	3228	9.69	14	3640	10.1	16	4160	10.9	191**
Nitrogen	Unit /Fed.	121	4114	12.3	126	4410	12.2	130	4550	12.0	16**
Phosphate	Unit /Fed.	31	992	2.98	33	1089	3.01	36	1188	3.12	3.2*
potassium	Unit /Fed.	24	815	2.45	26	910	2.52	29	1015	2.67	18**
Pesticide units	Liter/Fed.	7	2799	8.40	8	3200	8.85	9	3420	8.98	65**
Variable costs	EGP/Fed.	-	25328	76.0	-	28170	77.9	-	30073	79.0	387**
the rent	EGP/Fed.	-	8000	24.0	-	8000	22.1	-	8000	21.0	-
Total Costs	**EGP/Fed.**	**-**	**33328**	**100**	**-**	**36170**	**100**	**-**	**38073**	**100**	**387****
Productivity	Ton /Fed.	3.500	45010	-	3.0800	39609	-	2.800	36008	-	261**
Silage without Cobs	Ton /Fed.	13.00	8060	-	13.500	8438	-	14.00	8820	-	15**
Total Return	EGP/Fed.	-	53070	-	-	48047	-	-	44828	-	180**
Net Return	EGP/Fed.	-	19742	-	-	11877	-	-	6755	-	400**
Relative Profitability	%	-	-	78.1	-	-	42.2	-	-	22.5	467**
Return on Investment	EGP	-	0.59	-	-	0.33	-	-	0.18	-	455**
Profit Margin Ratio	%	-	-	37.1	-	-	24.7	-	-	15.1	478**

Profit per Ton	EGP/Ton	-	5641	-	-	3856	-	-	2412	-	429**

EGP = Egyptian Pound
Source: collected and calculated from the data of the questionnaire form in the study sample.

Automated labor: The cost of automated labor spent on a feddan of the maize yellow varieties under study amounted to approximately (4200, 4950, 5440) EGP/fed., representing 12.6%, 13.7%, and 14.3%, respectively, of the total costs of the crop.
Seeds: The cost of the quantity of seeds for planting one feddan of the maize yellow Single Hybrid variety 3444, 3084, 2055, in the research area amounted to about 3600, 3701, 3300 EGP/fed. Respectively, it is about 10.8%, 10.2%, and 8.67% of the total cost of feddan.
The Manure fertilizer: It was found that the cost of the manure fertilizer required to cultivate one feddan of the maize yellow Single Hybrid variety (3444, 3084, 2055) in Beheira Governorate is about 3228, 3640, 4160 EGP/fed., representing about 9.69%, 10.1%, 10.9% respectively of the total costs.
Chemical fertilizers: The data in Table 9 indicate that the cost of chemical fertilizers (nitrogen, phosphate, potassium) for maize farmers of the maize yellow Single Hybrid Varieties 3444, 3084, 2055 in Beheira, where the cost of nitrogen fertilizer amounted to about 4114, 4410, 4550 EGP/fed., representing about 12.3%, 12.2%, 12% respectively, and the cost of phosphate fertilizer amounted to about 992, 1089, 1188 EGP/fed., representing about 2.98%, 3.01%, 3.12% respectively of the total costs for each variety, and finally the cost of potassium fertilizer amounted to about 815, 910, 1015 EGP/fed., representing about 2.45%, 2.52%, 2.67% respectively of the total costs for each variety.
The pesticides: The cost of pesticides for pest and weed control per feddan of maize yellow crop for the three varieties under study in Beheira Governorate amounted to approximately 2799, 3200, and 3420 EGP/fed., representing about 8.4%, 8.85%, and 8.98% of the total costs for each variety, respectively.
Variable costs: The total variable costs per feddan of the maize yellow Single Hybrid Varieties 3444, 3084, 2055 in Beheira Governorate amounted to approximately 25328, 28170, 30073 EGP/fed., representing about 76%, 77.9%, and 79% respectively of the total costs for each variety.
The cost of renting one feddan of maize yellow crop reached about 8000 EGP/fed., representing about 24%, 22.1%, and 21% respectively of the total costs for each variety.

The results in Table 9 show that the variety 3444 of maize yellow in Beheira Governorate outperformed its counterpart two varieties, 3084 and 2055, in the productivity per feddan, which amounted to about 3.500 tons/fed., by a percentage of 13.6% and 25% respectively, this resulted in an increase in the total revenue to about 53070 EGP/fed., this was reflected in an increase in the net return per feddan to about 19742 EGP/fed., compared to the two varieties mentioned above, this resulted in an increase in the profitability per ton for the variety 3444 to 5641 EGP/ton.

The analysis also indicated that the relative profitability of the maize yellow Single Hybrid Varieties 3444, 3084, 2055 in Beheira Governorate reached about 78.1%, 42.2%, and 22.5%, which means that the farmer of Single Hybrid variety 3444 in Beheira is characterized by high productivity efficiency in employing production elements better than the farmer of the single variety 3084, 2055 for the production season of 2024.

Regarding the return on the pound invested for the maize yellow Single Hybrid Varieties 3444, 3084, and 2055 under study in Beheira Governorate, which amounted to approximately 0.59, 0.33, and 0.18 EGP, it was found that the best return per EGP was for the variety 3444, indicating that expanding the cultivation of this variety gives the best return per EGP compared to its counterparts under study. By comparing the maize yellow varieties under study in terms of the profit margin percentage, it was found that the best variety, the variety 3444, gives the highest profit margin percentage compared to its counterparts, amounting to 37.1% for the production season of 2024.

Fourth: Measuring the effect of technological change in maize yellow varieties on total factors productivity of the research sample in Beheira Governorate for the summer production season of 2024.

This section explains the results of the total factor productivity of the production inputs used in the production of the maize yellow Single Hybrid Varieties 3444, 3084 and 2055 in Beheira Governorate, which are (agricultural labor, automated labor, seeds, manure fertilizer units, nitrogen the fertilizer units, phosphate the fertilizer units, potassium the fertilizer units and pesticides) and the maize production of these varieties, compare the production of these varieties to identify which variety is the most efficient in producing the crop, which contributes to the optimal use of production inputs as follows:

Reviewing the results in Table 10, it was found that the change in the Malmquist index for the total

factor productivity of farmers using Single Hybrid variety 3444 in maize yellow production compared to Single Hybrid two Varieties 3084, 2055, and farmers using Single Hybrid variety 3084 compared to Single Hybrid variety 2055 in Beheira Governorate is greater than one, meaning that there is a positive effect of the technological change without a change in production inputs for farmers using Single Hybrid two Varieties 3444 and 3084. In the previous comparison, it was found that the best positive technological change for Single Hybrid variety 3444 reached about 15.1% and 47.8% compared to its counterpart Single Hybrid two Varieties 3084 and 2055 respectively, and the best positive technological change also for Single Hybrid variety 3084 reached about 26.2% compared to its counterpart Single Hybrid variety 2055.

And estimating the technological growth rate of total factor productivity in Table 10: It was found that when the farmer planted the maize yellow Single Hybrid variety 3444 in Beheira Governorate, it resulted in an improvement in total factor productivity of 15.1% and 44.8%, which is a better positive effect than planting the maize yellow Single Hybrid varieties 3084 and 2055 respectively. As for Single Hybrid variety 3084, when the farmer replaced Single Hybrid variety 2055 with it, it led to an improvement in total factor productivity of 23.7%, which is a better positive effect than planting Single Hybrid variety 2055 in the production of maize crop in Beheira Governorate, as shown in Table 10.

Table10: The technological change in the maize yellow Single Hybrid varieties affected the total factors productivity in the Beheira Governorate in the research sample.

maize yellow Varieties	Techch[1]	techch %[2]	Tfpch [3]	tfpch %[4]
3444	1.000	0.00	1.000	0.00
3084	1.151	15.1	1.151	15.1
3444	1.000	0.00	1.000	0.00
2055	1.478	47.8	1.448	44.8
3084	1.000	0.00	1.000	0.00
2055	1.262	26.2	1.237	23.7

(1) Technological change = (techch)
(2) % Technological change = (techch-1) x 100
(3) Total factor productivity = (tfpch)
(4) growth rate of productivity = (tfpch-1) x 100
Source: collected and calculated from the data of the questionnaire form in the study sample.

From the previous narrative in the research, it became clear that the maize Single Hybrid variety 3444 was superior to the maize Single Hybrid Varieties 3084 and 2055 in productivity per feddan, which resulted in an increase in profitability per ton. Therefore, it was characterized by high productivity and efficiency in using production factors and gives the best return on the invested pound and the best profit margin per ton when expanding its cultivation in the research area in Beheira Governorate. By measuring the effect of the technological change in the maize yellow varieties of Beheira Governorate, the single variety 3444 was also superior in bringing about an improvement in the productivity of total factors by about 15.1% and 44.8% compared to the single Varieties 3084 and 2055, and the best positive technological change amounted to about 15.1% and 47.8% respectively compared to the two varieties mentioned previously.

Based on the previous results, the single variety 3444 of maize yellow in Beheira Governorate has economic importance and a positive impact on technological change, in addition to leading to an improvement in the productivity of total factors compared to the single varieties 3084 and 2055. With the continued cultivation of this aforementioned variety in the future, a proposal or scenario was developed, the application of which would lead to an increase in the production of maize yellow in Beheira Governorate and Egypt and a reduction in the quantity of maize imports.

Fifth: The effect of replacing the higher-productivity of the maize yellow 3444 with the lower-productivity varieties on the total production of maize yellow in Egypt and the research area.

Table 11: shows that when expanding the cultivation of the single variety 3444 of maize yellow in the research area and at the level of Beheira Governorate, given that it gives the highest productivity per feddan compared to other varieties, replacing the cultivation of single varieties 3084 and 2055 with this variety leads to an increase in the productivity per feddan of yellow maize in the research area by about 0.420 and 0.700 tons/fed.. This leads to an increase in the net return per feddan by about 1619 and 1688 EGP/fed., respectively.

Table11: Cultivating the higher-productivity maize yellow variety in place of the lower-productivity varieties of the research area.

Production	Unit	maize yellow varieties		
		3444	3084	2055
highest Productivity of maize Variety	Ton/Fed.	3.500	3.500	3.500
Actual Productivity	Ton /Fed.	3.500	3.080	2.800
The increase in feddan productivity	Ton /Fed.	-	0.420	0.700
The increase in feddan return	EGP/Fed.	-	6552	11207
The increase in feddan costs	EGP/Fed.	-	4933	9519
The increase in feddan net return	EGP/Fed.	-	1619	1688

Source: Collected and calculated from the data of the questionnaire and table 9.

Table (1, 11) shows that the area cultivated with the single maize yellow varieties 3084 and 2055 in the research area (Koum Hamada, Kafr El Dawwar, Damanhur) for the production season 2024 amounted to approximately (11.3, 3.7) thousand feddans respectively. If farmers of these varieties were to plant the single variety 3444 instead of the aforementioned varieties, this would lead to an increase in maize yellow production in the research area of approximately (4.74, 2.6) thousand tons respectively, leading to an increase in net revenue in the research area of approximately (18.3, 6.22) million EGP for the area replaced by the single variety 3444. At the level of Beheira Governorate, the production of the maize yellow crop can be increased by planting the single maize variety 3444 instead of varieties 3084 and 2055, the area of maize yellow in Beheira with the two aforementioned varieties during the production season 2024 amounted to approximately (167.6, 28.3, 14.4) thousand feddans respectively, according to the data received from the Beheira Agriculture Directorate. Therefore, the production of maize yellow in Beheira Governorate can be increased by expanding and replacing the single variety 3444 with the two varieties mentioned above. Production will reach (11.9, 10.1) thousand tons respectively, with an increase of about (14.2%, 24.3%) of the production quantity of the single varieties 3084, 2055, which amounted to (83.9, 41.6) thousand tons respectively. This results in an increase in the governorate's production quantity by 4.53% of Beheira production quantity, which amounted to about 485.8 thousand tons during the season under study.

Based on the data in Tables 3, 6, and 11, the average area cultivated with maize yellow during the study period was 687.4 and 108.2 thousand feddans in Egypt and Beheira Governorate. The average total production for the crop during the same period was approximately 2157.7 and 364.6 thousand tons, respectively. Therefore, planting the maize yellow variety 3444 in place of the less productive varieties 3084 and 2055, will lead to an increase in crop production of approximately 288.7 and 45.4 thousand tons, respectively, representing an increase of approximately 13.4% and 12.5% in Egypt and Beheira. Similarly, planting the 3444 variety in place of the 2055 variety will result in an increase in production. The crop was approximately (481.2, 75.7) thousand tons, with an increase of approximately (22.3%, 20.8%) respectively.

By studying the effect of planting the maize yellow single variety 3444 in place of the maize yellow single varieties 3084 and 2055 on the average quantity of maize yellow imports during the study period of 7.25 million tons in Egypt, it was found that it would lead to an increase in the average production of about 384.9 thousand tons, an increase of about 17.8%, which would result in a decrease in the quantity of imports of the crop of about 384.9 thousand tons, a decrease of about 5.3%, which would result in reducing the costs of importing yellow maize by about 1.46 billion EGP, a decrease of about 5.3% from the average of the period under study.

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