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Economic impact for the adoption of the recommended improved varieties on wheat production in Egypt

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Abstract

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The study tries to answer questions e.g. what are the economic impacts of using of improved varieties recommended by the National Campaign to Uprise Wheat Production (NCUWP)? The results revealed farmers within NCUWP added about 1.564 ton/ha to the average yield gained by farmers without NCUWP. Farmers of NCUWP achieved more economic efficiency in terms of total revenue per ha. This could be due to increasing the yield and decreasing the costs of production. The results showed statistically significant effect of improved varieties on increasing wheat production. About 71% of the changes in wheat production was attributed to changing the quantities of seeds, organic fertilizers, nitrogenous and phosphorus fertilizers, labour and mechanical work. Education, off-farm employment, and making bread at home were the most important determinants of the decision to adopt these varieties. Our results showed that high costs of production and low level of water are the key problems facing farmers in the study sample. Capacity building for extension agents is essential for disseminating the improved varieties of NCUWP, as well as providing the agricultural extension service with enough number of agents.

Keywords: production function; elasticity; efficiency; technology; B/C ratio; Double Hurdle (DH) model

Introduction

Egypt is making great efforts to increase agricultural production to meet the rising demand on agricultural products. Due to the limited agricultural resources, the Egyptian government focused on vertical expansion as one of the important pillars to achieve agricultural development through disseminating improved crop varieties including high yield, drought-resistant, early mature and salt-tolerant varieties (Hamada, 2015) . On the other hand, food loss and wastage constitute a big share of wheat supply in Egypt (Yigezu et al., 2021).

Wheat is the most important cereal crop in Egypt due to its importance in the Egyptian diet. However, the local wheat production does not meet its domestic consumption. For more than 30 years, the Egyptian Government promoted a National Campaign to Uprise Wheat Production (NCUWP). Based on ARC (2017), this Campaign aims to boost wheat production through providing the farmers with the seeds (about 108 kg/ha) of a group of new improved wheat varieties for free, and providing them with technical support during the growing season, as well. The group of recommended wheat varieties includes 16 different varieties that are suitable for each agro-climatic conditions in each governorate.

The group of 16 new improved wheat varieties recommended by the NCUWP for the 2018/2019 season include seven varieties recommended for all regions namely; Gemmiza11, Giza168, Sakha94, Sids14, Shandaweel1, Misr1, Misr2, and two varieties recommended for Lower and Middle Egypt (Gemmiza12 and Giza171). On the other hand, six varieties are recommended for Middle and Upper Egypt namely; Sids12, Beni Suef1, Beni Suef5, Beni Suef6, Sohag4, Sohag5. All of these varieties are hard ones, except for Sids12 that is recommended only for Fayoum Governorate. Finally, Gemmiza9 is recommended only for Lower Egypt (ARC, 2019).

However, it is worth mentioning that, the recommended improved varieties are included in the technical package recommended by NCUWP for improving wheat production in Egypt. The package includes also planting date, planting method, seeding rate, ...etc.

In this regard, ElAfify (2013) used "Likert Scale" to identify the most important factors affecting farmer's choice to use improved varieties of wheat. The study highlighted significant positive relationship between grain yield, resistance to drought and rust, straw yield and farmer's choice whereas, significant positive relationship between the owned number of farm animals, farm size and farmer's choice was concluded in this study. Moreover, Hamdoon (2013) used Harry W. Ayer and Edward Schuh model and concluded that using improved wheat varieties lead to shifting the supply curve of wheat rightward. Hence, the replacement of low-yielding traditional varieties with the high-yielding improved varieties increases the total production of wheat. Furthermore, Ibrahim (2013) studied the impact of using improved varieties on the economic efficiency indicators of wheat in Al Sharkia Governorate using some economic efficiency indica-

tors. The results revealed significant increase in the yields, total revenue, and gross margins between the users and non-users of this technology for the sake of the formers whereas, the average costs where higher for the users of this technology. Moreover, the estimation of the production function and reported an increase in the average yield of wheat grains varied upon each technology package used; mainly improved varieties with some other components (Gado & ElBegawy, 2012). On the other hand, Arram and Abdullah, (2006) used analysis of variance and Chi-square and highlighted the significant relationship between level of education, farmer's income, agricultural experience, farm size, distance between the farm and the demonstration trial fields, seed price and the adoption new improved varieties of wheat. Besides, Sultan & Farid (2010) used Harry W. Ayer and Edward Schuh model and revealed that using improved varieties of wheat and maize led to shifting the supply curve rightward, increasing the production of wheat and maize.

Notably, MALR, (2020) revealed that wheat production in Egypt reached about 8.9 million tons/year during the period (2015-2019). Seven governorates; namely Al Sharkia, Al Buhayrah, Al Dakahlia, Al Minya, Kafr El Sheikh, Assiut, Sohag contribute to approximately 58.7% of this production (Elsayed et al., 2020).

The current study tries to answer questions; namely what are the economic impacts of using improved varieties recommended by the NCUWP? what are the factors that influence the decision to adopt these varieties? what are the main problems facing wheat farmers? Therefore, the research aims to measure the economic impacts of using improved varieties recommended by the NCUWP, to identify the determinants of the decision to adopt the improved wheat varieties recommended by NCUWP, and to identify the main problems facing wheat farmers.

In order to reach these objectives, the study is divided into three further sections. In the second section, the methodological framework is provided whereas, results and discussions are presented in the third section. The last section concludes with some remarks and recommendations on policy implications.

Material and Methods

Data source and analysis

Study area: The study covered the seven most important wheat-producing governorates inside the Nile Valley during the period (2015-2019). These governorates constitute about 57.8% of the Egyptian wheat average area that reached approximately 1.35 million hectares. The study area covers Sharkia, Beheira, Dakahlia and Kafr El Sheikh governorates (representing Lower Egypt), Minya governorate (representing Middle Egypt), and Assiut and Sohag governorates (representing Upper Egypt). Wheat area in Lower Egypt, Middle Egypt and Upper Egypt respectively represented about 5%, 18.5%, 19.3% of the Egyptian wheat average area. Moreover, the NCUWP considers these seven governorates as a potential for boosting wheat production in Egypt.

Data sources: Data were collected from a socio-economic survey conducted during winter season of 2018/2019 in the previously-mentioned governorates.

Sampling techniques and size: The sample households were distributed across the three regions of the study area. The research team purposively included the seven potential most important wheat-producing governorates of the NCUWP. Afterwards, a multi-stage stratified random sampling procedure was used to draw samples. To do this, first districts and villages were stratified into the demonstration farmers of the NCUWP who hosted the field trials so called "demo farmers" districts and villages and the traditional neighboring farmers so called "neighboring farmers" districts and villages (ARC, 2018). Since this study did not obtain any financial support, the sample households were then distributed across all seven governorates, based on the limited transportation costs available to the research team and household's cooperation with the data collector, as well. The sample included 50 of wheat farmers representing Lower Egypt (divided into 25 of the demo farmers and 25 of the neighboring farmers), 20 of wheat farmers representing Middle Egypt (including 10 of the demo farmers and 10 of the neighboring farmers), and 30 of wheat farmers representing Upper Egypt (including 15 of the demo farmers and 15 of the neighboring farmers). Therefore, the sample size was 100 of wheat farmers.

Analytical methods

To reach the objectives of the current study, frequency tables representing absolute frequency and relative frequency (or percent) and quantitative methods were used (Wildt & Ahtola, 2011). Moreover, a t-test was conducted to compare the differences between the demo and neighbouring farmers in terms of the characteristics and the average yields. A one-way Analysis Of Variance (ANOVA) was conducted to compare the effects of farmers' characteristics on farmers' decisions, as well (Hamed & Amina, 2015).

Data were also used to estimate wheat production function (Johnston,1984) using SPSS package. The production function was estimated using different forms including linear, log-linear, log-log (Cobb-Douglas) and quadratic (Johnston, 1984). Correlation matrix between variables was used to test Multicollinearity problem. The form that had the best fit for the given data set included six independent variables (e.g. seeds, organic manure, nitrogenous fertilizers, phosphorus fertilizers, labour and mechanical labor), and a dummy variable for using the recommended improved varieties as given below:

$$\text{Ln}(Y_i) = b_0 + b_1 \text{Ln}(X_{1i}) + b_2 \text{Ln}(X_{2i}) + b_3 \text{Ln}(X_{3i}) + b_4 \text{Ln}(X_{4i}) + b_5 \text{Ln}(X_{5i}) + b_6 \text{Ln}(X_{6i}) + b_7 (D) + U_i,$$

where:

'Y' the yields of wheat (ton/ha); 'X_1' quantity of seeds in kg/ha;

'X_2' quantity of organic manure in m^3/ha; 'X_3' quantity of nitrogenous fertilizers in kg/ha;

'X_4' quantity of phosphorus fertilizers in kg/ha; 'X_5' labour (man-day/ha);

'X_6' Mechanical labor (hour/ha);

'D' dummy variable for using the recommended improved varieties (D=1 if using, D=0 otherwise); 'i' denotes farm; 'b_0, b_1, b_2, b_3, b_4, b_5, b_6, and b_7' coefficients to be estimated;

'U' error term.

The Durbin Watson (DW) statistic was used to test autocorrelation problem in the residuals. To test for positive autocorrelation at significance α, the test statistic d is compared to lower and upper critical values ($d_{L,\alpha}$ and $d_{U,\alpha}$):

− If $d < d_{L,\alpha}$, there is statistical evidence that the error terms are positively autocorrelated.

− If $d > d_{U,\alpha}$, there is no statistical evidence that the error terms are positively autocorrelated.

− If $d_{L,\alpha} < d < d_{U,\alpha}$, the test is inconclusive.

To test for negative auto-correlation at significance α, the test statistic (4 − d) is compared to lower and upper critical values ($d_{L,\alpha}$ and $d_{U,\alpha}$):

− If (4 − d) < $d_{L,\alpha}$, there is statistical evidence that the error terms are negatively autocorrelated.

− If (4 − d) > $d_{U,\alpha}$, there is no statistical evidence that the error terms are negatively autocorrelated.

− If $d_{L,\alpha} < (4 - d) < d_{U,\alpha}$, the test is inconclusive

Furthermore, the main indicators of economic efficiency for wheat grown in the study area were calculated. The forms of these indicators are represented in the following formulas:

Total revenue per ha (in USD) = Yield (ton/ha) × Farm-gate price (USD/ton)

Net revenue per ha (in USD) = Total revenue (USD/ha) - Total costs (USD/ha)

Gross margin per ha (in USD) = Total revenue (USD/ha) - Variable costs (USD/ha)

Marginal cost per ton (in USD) = Variable costs per ha (in USD) ÷ Yield (ton/ha)

Total revenue per ton (in USD) = Total revenue (USD/ha) ÷ Yield (ton/ha)

Net revenue per ton (in USD) = Net profit per ha (USD) ÷ Yield (ton/ha)

Gross margin per ton (in USD) = Gross margin per ha (USD) ÷ yield (ton/ha)

Farmer's incentive (%) = [Net profit per ton (USD) ÷ Farm-gate price (USD/ton)] × 100

Benefit/Cost ratio per ha (in USD) = Total Revenue per ha (USD) ÷ Total Costs per ha (USD)

The double hurdle (DH) model was also used by means of Stata/SE15.1 to determine the decision to adopt the improved wheat varieties recommended by NCUWP and identify the size of area of land to be devoted to these components once the adoption decision is made (Solomon et al., 2014).

Results and Discussion

Characteristics of the study sample

Farmer's characteristics

Family size: Table 1 revealed that family size for the whole study sample reached 6 persons in average, as compared to 5 and 7 persons for the demo and the neighbouring farmers, respectively.

Sex of household head: Almost all of the household heads selected for the study sample were males (99%) whereas, only 1% were females.

Age of household head: The average age of the household heads reached about 55 years for the whole sample whereas, the age of household heads reached 57 years for the demo farmers and 54 years for the neighbouring farmers.

Farm size: Farm size reached about 1.255 ha in average for the whole study sample meanwhile, it reached about 1.426 and 1.084 ha for the demo and neighbouring farmers, respectively. The majority (69%) of farmers cultivated approximately 0.42-2.10 ha in average. Other categories of farm size namely; more than 2.10 ha and less than 0.42 ha represented approximately 19% and 12% in that order. As for the demo farmers, respectively about 78% and 22% cultivated 0.42-2.10 ha and more than 2.10 ha whereas, about 60%, 24% and 16% of the neighbouring farmers cultivated 0.42-2.10 ha, less than 0.42 ha and more than 2.10 ha in that order. The results indicated significant differences between the demo and neighbouring farmers in terms of farm size.

Land tenure: Owned lands were dominant in the study sample since most of the sample farms (84%) were owned by the farmers. Considering the sample farms leased to others and shared with others, the results showed that they represented approximately 11% and 5% of the sample farms in that order. As for the demo farmers, respectively about 90%, 6% and 4% owned their lands, shared their lands with others and leased their lands to others meanwhile, approximately 78%, 18% and 4% of the neighbouring farmers owned their lands, leased their lands to others and shared their lands with others (Table 1).

Level of education: About 46% of the demo farmer's family members were non-educated (e.g. illiterate and can hardly read and write). Educated family members of the demo farmers; primary & preparatory and high school graduates and university graduates constitute about 38 and 16%, respectively. As for the neighbouring farmers, about 49.8%, 41.2 and 9% of family members were non-educated, educated and university graduates in that order.

Table 1. Characteristics of the study sample

Characteristics	Demo Farmers	Neighboring Farmers	Total sample	Test statistic
	Mean		t_{test}	
Household size (Person)	5	7	6	(5.2)***
Age of household head (Year)	57	54	55	1.28
Farming Experience (Year)	35	31	33	1.69**
Farm Size (ha)	1.426	1.084	1.255	1.55*
	% Aggregate of farmers		F_{test}	
Farm Size:				
Less than 0.42 ha	0	24	12	4.47**
0.42 – 2.10 ha	78	60	69	
More than 2.10 ha	22	16	19	
Land tenure:				
Owned	90	78	84	4.14**
Shared with others	6	4	5	
Rented	4	18	11	
Level of education for farmer's family:				
Illiterate	20	22	21	3.92**
Can Read & Write	26	27.8	27	
Prim. & Prep. School	18	19	18.5	
High School Graduates	20	22.2	21	
University Graduates	16	9	12.5	
Main profession for farmer's family:				
Farming activities	35.4	34	34.7	9.94***
Non-farming activities	17.4	12.4	15	
Idle	47.2	53.6	50.3	

*, ** and *** Indicates statistically significant at 10%, 5% and 1% respectively.

Source: The results of the survey 2018/2019.

Main profession: About 35.4% of the demo farmer's family members worked in farming activities as their main profession while, approximately 17.4% and 47.2% of them practiced non-farming activities and were idle, respectively. Considering the neighbouring farmers, respectively about 53.6%, 34% and 12.4% of their family members practiced farming activities, were idle, and practiced non-farming activities (Table 1). Moreover, only about 2.5% of the household heads for the demo farmers gained off-farm income, as compared to approximately 3% for the neighbouring farmers.

The over-all results of Table 1 indicated statistically significant differences between the demo and neighboring farmers in terms of household size, farming experience, farm size, land tenure, level of education and main profession. However; no significant differences were observed between the demo and neighbouring farmers in terms of age of household head.

Cropping pattern

Wheat was dominant in winter, contributing to more than a half (57%) of the cropped area. Furthermore, approximately 20.2%, 9.7% and 7.7% of the cropped area was occupied by clover, faba beans and sugar beet, respectively. The rest of the cropped area (5.4%) was occupied by other winter crops. In the summer season, maize was dominant, representing about 38.5% of the cropped area. Moreover, 20.6%, 14% and 9.6% of the cropped area was occupied by rice, sorghum and yellow corn. The rest of the cropped area (17.3%) was occupied by other summer crops.

Economic impacts of the recommended improved varieties on wheat production in the study sample

The yield of wheat varieties

Table 2 revealed that the average yield of wheat for the demo farmers exceeded that yield obtained by the neighboring farmers by about 26%, reaching 1.564 ton/ha. This result indicates that following the recommendations by the NCUWP boosts wheat yield (ARC, 2018). Some wheat varieties (e.g. Giza171, Sakha94, Giza168 and Beni Suef1) grown by the demo farmers obtained high yields that exceed the average yield of wheat in the study sample. The yields of these varieties reached about 7.854, 7.679, 7.615, and 7.586 ton/ha, respectively. on the other hand, some wheat varieties (e.g. Beni Suef5, Beni Suef1, Gemmiza12, Giza168, and Misr1) grown by the neighboring farmers obtained high yields that exceed the average yield of wheat in the study sample. The yields of these varieties reached approximately 6.783, 6.712, 6.455, 6.347 and 6.048 ton/ha in that order. The yield of Misr2 grown by the demo farmers obtained the highest yield gap, exceeding that one grown by the neighboring farmers by about 1.785 ton/ha (33.3%). On the other hand, the yield of Beni Suef5 grown by the demo farmers obtained the least yield gap, achieving only 0.428 ton/ha (6.3%) over the yield of Beni Suef5 grown by the neighboring farmers. It is worth mentioning that, Sakha94 and Giza171 were grown only by the demo farmers since both varieties were recently introduced meanwhile, Gemmiza12, Sakha93, Sids12, and Sakha92 were not grown by the demo farmers since these varieties were excluded from the recommended list of varieties by the NCUWP.

Table 2. Yields of wheat varieties in study sample

Variety	Productivity, ton/ha		difference	
	Demo Farmers	Neighboring Farmers	ton	Change, %
Misr1	7.526	6.048	+1.478	24.4
Misr2	7.140	5.355	+1.785	33.3
Beni Suef5	7.211	6.783	+0.428	6.3
Gemmiza11	7.468	5.912	+1.556	26.3
Beni Suef1	7.586	6.569	+1.017	15.5
Giza168	7.615	6.347	+1.268	20
Sakha94	7.679	–	–	–
Giza171	7.854	–	–	–
Sids12	–	5.587	–	–
Gemmiza12	–	6.401	–	–
Sakha93	–	5.823	–	–
Sakha92	–	5.355	–	–
Average	7.551	5.987	+1.564**	26

*** indicates statistically significant at 1%.
Source: The results of the survey 2018/2019.

The impact of using the recommended improved varieties on the economic efficiency of wheat

Total and marginal costs per ha: The results of Table 3 indicated statistically insignificant effect of using the recommended improved varieties on the total and marginal costs for wheat grown in the demo and neighboring farms. The total and marginal costs of wheat grown in the demo farms exceeded the total and marginal costs of wheat grown in the neighboring farms by about 0.7% and 1.2% in that order.

Total revenue per ha: Our results showed that using the recommended improved varieties significantly and positively affected the total revenue of wheat since the demo farms gained approximately USD 402 exceeding that gained by their neighbors (20.6%) due to getting higher yields, indicating that the demo farmers gained more profits in terms of this indicator.

Net revenue per ha: Our findings revealed that using the recommended improved varieties has significant and positive impact on the net profit of wheat since the demo farms gained about USD 391 exceeding that gained by the neighbors (105%), indicating that the demo farmers gained more profits.

Total revenue per ton: Using the recommended improved varieties has statistically insignificant effect on the total revenue per ton of wheat in the demo and neighboring farms. The total revenue per ton of wheat in the demo farms was relatively lower than that one obtained by the neighbors by approximately 4.4% (Table 3).

Net revenue per ton: Our results showed that using the recommended improved varieties significantly and positively affected the net revenue of wheat since the demo farms gained approximately USD 39 exceeding that one gained by the neighbors (62.4%), indicating that the demo farmers gained more profits. This is attributed to the high yields obtained from the improved varieties grown by the demo farmers.

Gross margin per ha: Using the recommended improved varieties has significantly positive effect on the gross margin of wheat in favor of the demo farmers since they gained about USD 391 exceeding that one gained by their neighbors, representing about 38% over that gained by the neighbors, adding more profits to the demo farmers. This is due to the high yields obtained from the improved varieties.

Marginal costs per ton: The results of Table 3 indicated that using the recommended improved varieties significantly and negatively affected the marginal costs per ton of wheat in favor of the demo farmers since these

Table 3. Indicators of economic efficiency in the study sample

Indicator	Demo Farmers	Neighboring Farmers	Change	
			Value	%
Total costs per ha (USD)	1586.478	1575.885	10.593	0.7
Marginal costs per ha (USD)	929.683	919.090	10.593	1.2
Total revenue per ha (USD)	2348.220	1946.656	401.563**	20.6
Net revenue per ha (USD)	761.741	370.772	390.970**	105
Gross margin per ha (USD)	1418.536	1027.567	390.970**	38.0
Marginal cost per ton (USD)	123.046	153.511	-30.465**	-19.8
Total revenue per ton (USD)	310.981	325.147	-14.166	-4.4
Net revenue per ton (USD)	100.890	62.117	38.773**	62.4
Gross margin per ton (USD)	187.933	171.711	16.222**	9.4
Farmer's incentive (USD)	0.48	0.24	0.24**	100
Cost to Return Ratio per ha (USD)	1.48	1.24	0.24**	19.4

** indicates statistically significant difference at the 1% level.
Source: The results of the survey 2018/2019.

costs were lower for the demo farms than that of their neighbors by approximately 19.8% thus, adding more profits to the demo farmers in terms of this indicator (Table 3).

Net revenue per ton: Using the recommended improved varieties has significant and positive effect on the net profit per ton of wheat in favor of the demo farmers since they gained about 62.4% over that gained by the neighbors, indicating that demo farmers gained more profits in terms of this indicator.

Gross margin per ton: The results revealed that using the recommended improved varieties has significant and positive effect on the gross margin per ton of wheat grains in favor of the demo farmers since they gained approximately 9.4% over that one gained by the neighbors thus, adding more profits to the demo farmers.

Farmer's incentive: Our results showed that using the recommended improved varieties significantly and positively affected the percentage of farmer incentive of wheat in favor of the demo farmers since they gained 100% exceeding that gained by the neighbors, indicating that the demo farmers gained more profits in terms of this indicator.

Benefit/Cost ratio (B/C) per ha: Using the recommended improved varieties has a significant positive effect on the B/C of wheat in favor of the demo farmers, gaining about 19.4% over that gained by the neighbors, making more profits by the demo farmers.

Our over-all results reveled that using improved wheat varieties recommended by the NCUWP was more profitable in terms of total revenue. This could be due to increasing wheat yield and decreasing the costs of production (e.g., seeds and nitrogen fertilizer), as well.

The quantity of inputs used in wheat production

The results illustrated in Table 4 showed that the demo farmers used less seed rate by approximately 31.8% than the neighboring farmers used in their farms. This could be attributed to the fact that the demo farmers used raised bed or seed drilling techniques in wheat planting (Yigezu et al., 2021) whereas, the neighboring farmers used dry seed broadcasting method that requires adding more seeds instead. Moreover, the demo farmers respectively used less nitrogenous fertilizers and labor by about 30.0% and 21.5% than that used by the neighboring farmers. The reason behind this could be the tendency of the traditional farmers to add additional amounts

Table 4. Inputs of wheat production in the study sample

Input/ha	Demo Farmers	Neighboring Farmers	Change	
			Value	%
Seeds, kg	107	157	(50) **	(31.8)
Nitrogen fertilizer, kg	238	340	(102) **	(30.0)
Phosphorus fertilizers, kg	236	239	(3)	(1.3)
Organic manure, m^3	46	45	1	2.2
Pesticides, USD	32	29	3	10.3
Labor, man-day	51	65	(14) **	(21.5)
Mechanical labor, hour	62	48	14**	29.2

Note: values between brackets are negative.
** indicates statistically significant difference at the 1% level.
Source: The results of the survey 2018/2019.

of chemical fertilizers, especially nitrogenous fertilizers believing that it causes yield increase. On the contrary, the demo farmers used more mechanical labor by approximately 29.2% than that used by the neighboring farmers (e.g., planting, harvesting and threshing).

The impact of using the recommended improved varieties on the production function of wheat grown in the study area

The estimates of wheat production function are portrayed in Table 5. The F-value showed statically significance at the 5% level, implying that the independent variables significantly explained the variation in the dependent variable. The adjusted coefficient of determination (adj. R^2) indicated that the studied factors of wheat production explain 71% of the variation in wheat production whereas, the rest (29%) represents other factors not included in the estimated production function of wheat in the study area (e.g. wheat losses due to pest and/or disease infection). The results of Durbin Watson (DW) statistic indicated that no autocorrelation detected in the sample (Table 5).

The elasticity of seed rates, nitrogenous fertilizers and labor for the neighboring farmers are less than zero reaching approximately -24, -0.18 and -0.14, respectively. This result shows negative decreasing function to these inputs and indicates over-utilization of these inputs, implying that the

Table 5. Estimates of the production function for wheat in the study sample

Variable	Coefficient	T-statistic
Constant	+4.35	6.9*
X_{1i} (kg/ha)	(0.24)	(3.6) *
X_{2i} (m3/ha)	(0.002)	(0.069)
X_{3i} (kg/ha)	(0.18)	(3.42) *
X_{4i} (kg/ha)	+0.02	1.89
X_{5i} (man-day/ha)	(0.14)	(2.3) *
X_{6i} (hour/ha)	(0.19)	(1.89)
D	+0.28	7.997*
F-value	13.7*	
Adj. R^2	0.71	
EP (Elasticity of Production)	(0.45)	
Durbin-Watson (d)	1.871 where $d_{L.0.05}$ = 1.53 and $d_{U.0.05}$ = 1.83	

Note: values between brackets are negative.
* Indicates statistically significant difference at the 5% level.
Source: The results of the survey 2018/2019.

Table 6. Parameter estimates of the of Double Hurdle (DH) Model for using the recommended improved varieties

Explanatory variables	DH-Tier1				DH-Tier2			
	Coef.	Std. Err.	z	P>|z|	Coef.	Std. Err.	z	P>|z|
Education (years)	0.145	0.066	2.22	0.027	0.013	0.022	0.58	0.563
Family size	0.501	0.356	1.41	0.159	-0.175	0.077	-2.27	0.023
Sex (1=male, 0=female)					1.529	1.721	0.89	0.374
Off-farm employment (1=yes, 0=no)					1.775	0.283	6.28	0.000
Participation in NCUWP (1=yes, 0=no)	8.894	217.307	0.04	0.967				
Total owned area (ha)	-0.715	0.437	-1.64	0.102				
Making bread at home (1=yes, 0=no)	-6.361	284.398	-0.02	0.982	0.687	0.291	2.36	0.018
Can get adequate quantities of improved varieties when needed (1=yes, 0=no)	2.331	1.049	2.22	0.026				
Facing water-shortage problem (1=yes, 0=no)	-1.581	1.060	-1.49	0.136				
Facing soil salinity problem (1=yes, 0=no)	0.370	0.842	0.44	0.661				
Using improved varieties as seen in neighbour's field (1=yes, 0=no)	-0.267	0.697	-0.38	0.702				
Constant	5.148	284.400	0.02	0.986	0.578	1.799	0.32	0.748
sigma_cons	1.110	0.101	10.99	0.000				

Source: The results of the survey 2018/2019.

allocation and utilization of these inputs were in irrational stage of production (stage III) of the production process (Johnston, 1984). Furthermore, the elasticity of production is estimated at approximately -0.45, implying diminishing rates of returns.

The results showed that seed rates and nitrogenous fertilizers used by the neighboring farmers exceed the rates recommended by the NCUWP, negatively affecting wheat production. The neighboring farmers tend to use more seed rate as a result of late cultivation of wheat whereas, they tend to add additional amounts of nitrogenous fertilizers believing that it causes yield increase. Moreover, the neighboring farmers employ more family labor resulting in the negative effect on wheat production. The coefficient of the dummy variable revealed that using the improved wheat varieties recommended by the NCUWP increases wheat yield by about 28%.

Determinants of the decision to adopt the improved wheat varieties recommended by NCUWP and intensity of adoption

The results of the double hurdle (DH) model used to identify the factors that positively or negatively influence the decision to adopt the improved wheat varieties recommended by NCUWP and the size of area of land to be devoted to these components once the adoption decision is made are reported in Table 6.

The estimates show that family size and making bread at home have insignificant effect on the decision on whether to adopt improved varieties or not while family size has negative and significant ($p < 0.05$) effect on the intensity of adoption whereas, making bread at home has positive and significant ($p < 0.05$) effect on the intensity of adoption. This result suggests that while this variable don't have a significant effect in influencing farmers' decision, once a farmer has decided to use these varieties, making bread at home positively influence the area of land to be devoted to these varieties.

High-educated farmers have substantially higher propensity of adopting improved varieties - at significance level ($p < 0.05$). This variable is insignificant in the second hurdle model showing that being a high-educated farmer who uses improved varieties of wheat does not necessarily imply that the area of land devoted to improved wheat varieties is any larger than a similar low-educated farmers.

We found that off-farm employment increased the area of land to be devoted to such varieties, which should not come by surprise as only larger farmers can afford to allocate larger area to a given technology. Farmer's sex is statistically insignificant for the second hurdle equation. Moreover, getting adequate quantities of improved varieties when needed has a positive and significant effect ($p < 0.05$) on the decision to adoption in the first hurdle. It increases the propensity of adoption by 2.331.

The most important problems wheat farmers faced in the study sample

Our results revealed that high costs of inputs, low-quality of pesticides, low-quality of fertilizers, weakness of the agricultural extension role and unavailability of improved wheat seeds were the most important production problems prevailing in the study sample. As for irrigation problems, the results revealed that low level of water in the canals, irregular irrigation rotation, uncleaning the mesqas and using drainage and mixed water to compensate water shortage were the most important problems prevailing in the study sample. Considering soil problems, the results showed that high costs of land preparation, lack of sound mechanical services for land preparation, increase soil salinity and height of the ground water level were the most important problems prevailing in the study sample.

Conclusions

Wheat is considered the major staple food commodity for the Egyptian increasing population. However, the local wheat production does not cover the domestic consumption and consequently, boosting domestic wheat production is a national goal to narrow the gap between consumption and production and improve national food security (Elsayed *et al.*, 2020). This study analyzed the economic impact of using the improved wheat varieties recommended by the NCUWP in the study sample.

Empirical findings showed that the yields of improved wheat varieties recommended by the NCUWP exceeded those yields obtained by the neighboring farmers who did not use such varieties and gained the highest economic efficiency indictors, as well. Our findings were supported by Ahmed & Sabri (2016) and ElAfify (2013). Therefore, sufficient farmer's access to knowledge and improving communication channels between

farmers and agricultural extension and skilled extension personnel on management practices are of high importance to transfer such promising varieties to farmers. These findings are in agreement with those of (Morsey & Sharabin, 2021).

Our results showed that education and getting adequate quantities of improved varieties when needed have a significant effect ($p < 0.05$) on the decision to adopt improved varieties.

Moreover, the study concludes that high costs of inputs, low-quality of pesticides, low-quality of fertilizers, weakness of the agricultural extension role and unavailability of improved varieties of wheat seeds the main problems facing wheat farmers in the study sample. Our results are consistent with (Elsayed et al., 2021).

Based on these results, agricultural cooperatives are encouraged to provide wheat farmers with high-quality of inputs and improved varieties of wheat seeds recommended by the NCUWP to maintain obtaining high yield of wheat and get more income. Furthermore, following-up the mechanisms of the improved wheat varieties distribution system is a key pillar for maintain a successful distribution system. Empowering the Contractual Agriculture Center supports the marketing system through determining the price range for the supply of the wheat and announce it before the beginning of the wheat season. Providing farmers with adequate quantities of improved varieties at suitable time is of high importance to affect the decision to adoption.

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