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An Economic Study of the Quantitative Losses of Rice Crop in Dakahlia governorate

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Abstract: The main objectives of the study were to, estimate the physical and financial losses in rice in Dakahlia governorate, determinate factors responsible for losses and suggest ways to reduce them, and reached to that, the total quantitative production loss of rice for the whole governorate was estimated at about 327.5 thousand tons, at rate of about 23.3% of the governorate's total production of rice, to which the losses due to, not adopting recommended techniques, infection of diseases, pests and weeds, during harvest contributed by 45.2% , 46% , 8.9% respectively. The total marketing loss of rice in the governorate was estimated at about 89.5 thousand tons, transportation loss, storage loss and processing loss contributed by about 8%, 32.3%, 59.7% respectively. The consumption loss of rice was estimated at about 82.9 thousand tons. The total quantitative loss of rice in Dakahlia governorate was estimated at about 499.9 thousand tons, with a value of about 133.5 million dollars, production, marketing and consumption losses contributed by about 65.5%, 17.9%, 16.6% respectively.The total water loss in the governorate as a result of the rice loss was estimated at 980.7 million m^3.
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Key words: Rice, Quantitative, Losses, Dakahlia.

1. Introduction:

Rice crop is one of the pillars of food security in Egypt because of its importance in the food basket for both urban and rural residents and its important place in the cropping pattern in Egypt. with area recorded in 2019 at about 1.31 million feddans (Feddan is equal to about 4,200 m^2, equivalent to about 0.42 hectare.), at a rate of about 20.2% of total summer crops area. Rice also takes an important place in the Egyptian agricultural policy for considerations related to its high consumption of water, which at about 24.4% of the amount of water consumed in summer season in Egypt in 2019 (Ministry of irrigation and water resources, 2020).

About 1/3 of the food produced in the world per year for human consumption is lost or wasted. Food losses and waste total approximately 680 billion USD in industrialized countries and around 310 billion USD in developing countries (Barbara Sawicka, 2019).

Reducing loss is one of the ways of vertical agricultural development, as it increases the availability of the crop, in addition to re-planning the crop pattern and directing agricultural resources towards crops with higher economic efficiency in using those resources. The interest in studying losses in agricultural production has increased due to its great impact, whether at the farm level or at the national level. At the farm level, these losses affect farm income, which poses a great challenge to poverty reduction, especially in rural areas. At the national level, losses in agricultural production constitute a challenge to achieving food security.

Dakahlia governorate consider one of the main governorates in producing rice in Egypt with area recorded in 2019 at about 368.8 thousand feddans, about 28.3% and 70.2% of the total crop area in Egypt, and summer crops area in Dakahlia governorate, respectively, with production recorded at 1.4 million tons, at about 29.2% of the total production of rice in Egypt (Ministry of Agriculture, 2020).

The research problem:

Rice takes an important place in the Egyptian agricultural policy for considerations related to the preferences of the Egyptian consumer, and related to its high consumption of water, which at about 24.4% of the amount of water consumed in summer season in Egypt in 2019((Ministry of irrigation and water resources, 2020)). Therefore, the importance of the trend towards reducing its area in light of the water risks surrounding Egyptian agriculture. In this context, the importance of studying loss appears as one of the methods of vertical development by increasing the availability of the crop. The problem of the study is represented in the question of the amount and value of rice losses in Dakahlia governorate ?, and what are the ways to reduce these losses?

Objectives of the research:

1- To estimate the physical and financial production, marketing and consumption losses in rice in Dakahlia governorate.
2- To determinate factors responsible for such losses and suggest ways and means to reduce the extent of losses in different operations in order to increase national availability of rice.

The importance of studying loss (FAO. 2018)**:**

1. The reduction of food losses falls under several policy objectives, which require reliable data for decision-making.
2. Supporting the implementation and monitoring of international and regional commitments for the reduction of food loss.
3. Enhancing the accuracy of broader analytical frameworks, such as Supply-Utilization Accounts (SUAs) and Food Balance Sheets (FBSs).

Definition of food losses

Food Loss: Food losses are all the crop and livestock human-edible commodity quantities that, directly or indirectly, completely exit the post-harvest/slaughter production/supply chain by being discarded, incinerated or otherwise, and do not re-enter in any other utilization (such as animal feed, industrial use, etc.), up to, and excluding, the retail level (FAO, SDG12.3).

Quantitative food loss can be defined as reduction in weight of edible grain or food available for human consumption. Quantitative loss such as reduced nutrient value and unwanted changes to taste, color, texture, or cosmetic features of food. (FAO., 1980). Food losses take place at production and post- harvest stages in the food supply chain (FAO., 2011). Food redirected to non-food chains (including animal feed) is food loss or waste (FAO. 2014).

Production losses:

Occur before and during harvest, i.e. they are considered losses in the producing stages. Two general types of losses have been identified:

(a) Pre-harvest losses: Occur before the harvesting process begins and may be due to such factors as insects, weeds or diseases afflicting crops (FAO., 2015), and due to not adopting recommended modern techniques in planting and weeding (Salah ,E., Alwan. 2008).

(b) Harvest losses: Occur due to several reasons, the most important of which is the employment of improper harvesting methods such as: Rough handling; untimely harvesting; lack of appropriate and/or poorly-designed harvesting tools, equipment, and harvesting containers (Action Contre la Faim (ACF)., 2010).

Marketing losses:

Occur during the post-harvest period. They occur between harvest till the moment of human consumption .They include losses along the chain during transportation, storage and processing.

Method:

In the current study, production losses, marketing losses and consumption losses of rice will be estimated according to the following:1- Production Losses:

a- Pre-harvest Loss:

- Production loss due to not adopting recommended technological techniques, land laser leveling, planting new approved seeds and early planting date, by calculating the difference in yield between those who use these techniques and those who did not.

$$L_{Ptec} = Q_g - Q_c$$

L_{Ptec} : The physical production loss due to not adopting recommended modern techniques in planting and weeding, Q_g : The average yield with adopting recommended modern techniques , Q_c : The average yield without adopting.

- Production loss due to disease, pests and weeds: by calculating the difference in yield. between the cases with attack, and the cases without attack.

$$L_d = Q_w - Q_s$$

L_d : The physical production loss due to the attack of disease or pests or weeds, Q_w : The average yield without attack, Q_s : The average yield with attack.

b- during harvest.

- Losses during harvesting

The crop cutting plot was selected at random within the field. After the harvested produce was removed from the plot, all grains shed or missed were then carefully picked up for estimating harvest loss.

- Losses during stacking:

The stacks were built on a plastic sheet to collect all scattered grains when the bundles were later removed.

- Losses during threshing.

After threshing, the remaining straw was carefully examined for grain that had escaped from the threshing process and recorded.

$$L_P = L_{ptec} + L_h$$

L_P : The physical production loss, L_h : The physical production loss during harvest.

2- Marketing loss: Marketing loss of rice was studied in two phases as follows:

a- Study the marketing practice of rice.

b- estimating quantitative loss during the marketing stages L_M as follows:

- Estimating the physical loss during packing L_K .
- Estimating the physical loss during transportation L_T .
- Estimating the physical losses during storage L_S .
- Estimating the physical losses during processing L_R .

$$L_M = L_k + L_T + L_S + L_R$$

3-Consumption loss:

L_C : Consumption loss.

4-Total loss

$L = L_P + L_M + L_C$, L : Total loss.

5- Water loss:

$$WL = L * Q_W$$

WL : Water loss, Q_W : The amount of water consumed to produce a ton of paddy.

Descriptive measures were used to analyze both the secondary and primary data.

Data sources:

The sampling method was used to collect the primary data, and the study used the multi-stage random cluster sampling method to obtain the primary data for estimating the production, marketing and consumption losses of rice. Where the two largest centers in terms of the area cultivating with the rice crop in the governorate were chosen, the centers of Manzala and Belqas, where they represented about 36.7% of the total area cultivated with the crop in the governorate, Villages and observations were selected randomly, with 40 observations in each of the two selected centers, with a total of 80 observations for the study sample. Similarly, a similar sample was chosen from the merchants, rice millers, and consumers in the same centers and villages previously selected. The questionnaire forms were collected in 2019.The study also used the published and unpublished secondary data that serve the purposes of the research, which were obtained from Ministry of Agriculture, the Directorate of Agriculture in Dakahlia governorate, the Directorate of Water Resouces and Irrigation in Dakahlia governorate, in addition to researches and studies published in This regard.

3. Results:

1- Rice production indicators in Egypt and Dakahlia governorate:

1.1 The development of area, production and yield of rice crop in Egypt and Dakahlia governorate between the two periods (2000-2002), (2017-2019).

Through the study of the historical development of the most important productive indicators of the rice crop in Egypt between the period (2000-2002) and the period (2017-2019),which have been depicted in table 1, it is clear that the average area under rice crop in Egypt decreased from about 1,485.5 thousand feddans for the period (2000-2002), about 24.9% of the total summer crops area, to about 1156.5 thousand feddans for the period (2017-2019), about 17.4% of the total summer crops area, with a decreasing of about 329.1 thousand feddans, at a decreasing rate of about 22.2%. This is result of implementing a policy aimed at reducing rice crop area and limiting its production to meeting local consumption according to a strategy aimed at rationalizing water consumption in Egypt.

Table 1 also indicates that the crop yield was relatively stable between the two study periods, as it ranged from about 3.9 tons/feddan for the first period to about 3.7 tons/feddan for the second period. This was reflected in the total production, As it decreased from about 5777.3 thousand tons for the first period to about 4292.6 thousand tons for the second period, with a decreasing of about 1,484.7 thousand tons, with a decreasing rate of about 25.7%.

Table1: Production indicators of the rice crop in Egypt for two periods, (2000-2002) and (2017-2019).

Period	Area thousand feddans	% Of summer crops area	Yield Tons per feddan	Production thousand tons
First period average (2000-2002)	1485.5	24.9	3.9	5777.3
First period average (2017-2019)	1156.5	17.4	3.7	4292.6
Difference	-329.1		-0.2	-1484.7
Change Rate %	-22.2		-4.8	-25.7

Source: Collected and calculated from Ministry of Agriculture, Economic Affairs Sector, Agricultural Statistics Bulletin, Various issues.

The productive indicators of the rice crop in Dakahlia governorate for two periods (2000-2002) and (2017-2019) have been depicted in table 2, which indicates that the area under rice decreased from about 440.1 thousand feddans for the first period, about 79.7% of the summer crops area in the governorate and about 29.6% of the total rice area in Egypt, to about 329.8 thousand feddans for the second period, at about 62.1% of the summer crops area in the governorate and about 28.5% of the total rice area in Egypt, with a decreasing of about 110.3 thousand feddans, at a decreasing rate of about 25.1%.

Table 2 also shows that the crop yield was relatively stable between the two study periods, as it ranged from 4 tons/feddan for the first period to about 3.9 tons/feddan for the second period. This was reflected in the total production, as it decreased from about 1744.9 thousand tons for the first period to about 1289.6 thousand tons for the second period, with a decreasing of about 455.3 thousand tons, at a decreasing rate of about 26.1%.

1.2 Costs and profitability of rice crop:

The economic indicators of rice crop producing, which were obtained from the field questionnaire in Dakahlia governorate, have been presented in table 3. The total cost of producing rice crop was 10169 L.E. per feddan, as the variable cost was 6998 L.E., at about 68.8% of the total producing cost, while the fixed cost was 3171 L.E., at about 31.2%.

Table 3 also shows that the amount of seed used was about 82 kg/feddan, with a value of about 754 L.E., at about 7.4% of the total production cost. Machinery hours used was about 54 hours/feddan, with a value of about 2150 L.E., at about 21.1%. The human labor used was about 294 hours/feddan, with a value of about 3185 L.E., at about 31.3%. The amount of nitrogen fertilizer used was about 74.4 units/feddan, with a value of about 528 L.E., at about 5.2%. The amount of insecticides used was about 3.9 liters/feddan, with a value of about 380 L.E., at about 3.7%.

Table2: Production indicators of the rice crop in Dakahlia governorate for the two periods (2000-2002) and (2017-2019).

Period	Area Thousand feddans	% Of Summer crops area in governorate	% Of rice area in Egypt	Yield tons/feddan	Production thousand tons
First period average (2000-2002)	440.1	79.7	29.6	4.0	1744.9
First period average (2017-2019)	329.8	62.1	28.5	3.9	1289.6
Difference	-110.3			-0.1	-455.3
Change Rate %	-25.1			-2.5	-26.1

Source: Collected and calculated from Ministry of Agriculture, Economic Affairs Sector, Agricultural Statistics Bulletin, Various issues.

Table 3: Quantities of inputs, yield, costs and return of producing rice per feddan.

Items per feddan		quantity	value	% of the total cost
Variable cost	seeds	82.0	754	7.4
	Machinery	54.0	2150	21.1
	Labor	294	3185	31.3
	nitrogen Fertilizers	74.4	528	5.2
	Phosphate fertilizer	0.0	0.0	0.0
	Manure	0.0	0.0	0.0
	Insecticides	3.9	380	3.7
	Total		6998	68.8
Fixed cost	Rent		3026	29.8
	petty cash		145	1.4
	Total		3171	31.2
Total cost			10168	100.0
yield	Main crop	3.67	18350	
	secondary crop		300	
Total return			18650	
Net Return			8481	
Return/costs ratio			1.83	
Profit of the pound			0.83	

Source: Collected and calculated from the primary data, season 2019.

Table 3 also indicates that the average yield of rice was about 3.67 tons/feddan, with a value of 18,350 L.E., the average value of secondary production (straw) was about 300 L.E., achieving a total return of about 18650 L.E., with a net return of about 8481 L.E. and The return/costs ratio was estimated at 1.83, achieving a profit of the pound of about 0.83.

2-Estimating the quantitative production losses of rice crop in Dakahlia governorate.

2.1- Estimating the quantitative Pre-harvest losses of rice.

2.1.1- Estimating the quantitative losses of rice due to not adopting recommended modern techniques in planting and weeding:

Vertical development programs aimed to increase feddan yield through a set of techniques, numerous agricultural researches have reached many technical recommendations that would increase the efficiency of resource use and achieve an increase in feddan yield. The current section focused on studying production losses due to not adopting recommended techniques in the cultivation of rice crop, represented by using of land laser leveling, planting of new approved seeds and early planting. A questionnaire was conducted to study this loss by calculating the difference in yield between those who used those techniques and those who did not use them, and the results of the questionnaire were summarized in table 4.

Data in table 4 reveals that 8.8% of the total sample farmers, at about 13.5% of the total sample area, used the three techniques under study, with yield of about 4.05 tons/feddan. Table 5 shows also that 67.5% of the total sample farmers, at about 67.9% of the total sample area, used new approved seeds in agriculture and adopted early planting, with yield of about 3.66 tons/feddan and 16.3% of the total sample farmers, at about 14.4% of the total sample area, adopted early planting, with yield of about 3.39 tons/feddan, while 7.5% of the total sample farmers, at about 4.2% of the total sample area, did not adopt any of the three techniques under study, with yield of about 3.06 tons/feddan.

By calculating the differences in yield between those who used each of the techniques under study and those who did not use them, it was found that, non laser leveling of the land caused a loss of 390 kg/feddan, about 106.9 kg/ton, at a rate of about 10.7% of feddan yield, planting of old seeds from a previous season's crop caused a loss of 270 kg/feddan, about 74 kg/ton, at a rate of about 7.4% of feddan yield, and delaying the planting date caused a loss of 330 kg / feddan, about 90.4 kg / ton, at a rate of 9% of feddan yield.

Table 4: Estimating the quantitative production losses of rice due to not adopting recommended techniques in the study sample.

Techniques	Number of observations and its proportion for the total sample	Area of observations and its proportion for the total sample	Yield ton/feddan	Amount of the loss		
				kg/feddan	kg / ton	% of Feddan yield
1+2+3	7 (8.8%)	20.6 (13.5%)	4.05	--		
1+2	0 (0%)	0 (0%)				
1+3	0 (0%)	0 (0%)				
2+3	54 (67.5%)	103.5 (67.9%)	3.66	390	106.9	10.7
1	0 (0%)	0 (0%)				
2	0 (0%)	0 (0%)				
3	13 (16.3%)	22 (14.4%)	3.39	270	74	7.4
4	7 (7.5%)	6.3 (4.2%)	3.06	330	90.4	9
total	80 (100%)	152.4 (100%)	3.66			

1: Land laser leveling, 2: planting of new approved seeds and 3: early planting.
Source: Collected and calculated from the primary data, season 2019.

The percentages of rice area that did not use the techniques under study in the sample were calculated through the data contained in table 4 and results were tabulated in table 5. These percentages were about, 86.5% for non using the land laser leveling technique, 18.6% for using old seeds from a previous season's crop and 4.2% for delaying the planting date.

By generalizing previously estimated percentages for the whole rice area in the governorate, results in table 5 show that, the rice area unused the land laser leveling technique in the governorate was estimated at about 319 thousand feddans, the area used old seeds was about 68.6 thousand feddans and the area that was delayed in planting was about 15.3 thousand feddans.

According to both previously estimated areas and the sample estimates of losses, which were estimated at about 0.39, 0.27, and 0.33 ton/feddan respectively, the rice losses for the whole governorate were estimated and the results tabulated in table 5. The amount of rice loss due to non using the land laser leveling was estimated at about 124.4 thousand tons, the amount of loss due to the use of old seeds from a previous season's crop was estimated at about 18.5 thousand tons and the amount of loss due to delay of planting date was estimated at about 5.1 thousand tons, with a total of about 148 thousand tons, a rate of about 10.5% o of the governorate's total production of rice, at value of about 39.5 million dollars, equivalent to about 658.2 million L.E.

Table 5: Estimating the quantitative production losses of rice due to not adopting recommended techniques in Dakahlia Governorate.

Unused technique	percentage of the area in the sample %	Area in governorate thousand feddan*	Amount of the loss in the sample kg/ feddan	Amount of the loss in the Governorate thousand ton**	Value of the loss in the governorate million $	Value of the loss in the governorate million L.E.
Non- laser leveling of the land	0.865	319.0	0.39	124.4	33.2	553.4
planting of old seeds	0.186	68.6	0.27	18.5	4.9	82.4
delaying the planting date	0.042	15.3	0.33	5.1	1.4	22.5
total				148.0	39.5	658.2

*Area unused technique in the governorate = The percentage of rice area unused technique in the sample x total rice area in the governorate.

**Amount of rice loss in the governorate= Amount of rice loss in the sample per feddan x Area of rice unused technique in the governorate.

Source: calculated from Table 4.

The results of the questionnaire about the causes of not adopting recommended techniques in cultivation of rice indicated that, high cost of land laser leveling and the small size of holding were challenges to use land laser leveling, high prices of new approved seeds was the constraint for using it and the delay in harvesting the previous crop was the reason of delaying the planting date.

2.1.2- Estimating the quantitative losses of rice due to infection with disease, pests and weeds:

Diseases, pests and weeds are among the main reasons that cause a decrease in crop yield. For rice crop, there are many diseases, pests and weeds that infest it. Where, through the questionnaire, the incidence of rice blast, brown spot diseases was recorded. For pests, infection with Leaf hopper Green Rice, stink bug Rice and leaf borers were recorded, and the presence of weeds, Echinochloa crus-galli, Echinochloa colonum and Cyperus diffonnis.

Table 6 shows the percentages of infection with any of the diseases, pests and weeds according to what was recorded in the questionnaire prepared for this. About 11.2% of the total sample area did not record any infestation of any weeds, diseases or pests, with yield of about 4.03 tons/feddan. About 53.5% recorded weed infestation only, with yield of about 3.71 tons/feddan. About 13.5% recorded both diseases and weeds infestation, with yield of about 3.32 tons/feddan. About 8.5% recorded both pests and weeds infestation, with yield of about 3.62 tons/feddan. About 13.3% recorded both diseases and pests and weeds infestation, with yield of about 3.23 tons/feddan.

Table 6: Infection of diseases, pests and weeds in the study sample.

Infection	Number of observations and its proportion for a total sample	Area of observations and its proportion For a total sample	Yield ton/feddan
4	6 (7.5%)	17.1 (11.2%)	4.03
1	0 (0%)	0 (0%)	
2	0 (0%)	0 (0%)	
3	48 (60%)	81.6 (53.5%)	3.71
1+2	0 (0%)	0 (0%)	
1+3	10 (12.5%)	20.5 (13.5%)	3.32
2+3	7 (8.8%)	12.9 (8.5%)	3.62
1+2+3	9 (11.3%)	20.3 (13.3%)	3.23

1: infection with diseases, 2: infection with pests and 3: infection with weeds.
Source: Collected and calculated from the primary data, season 2019.

By calculating the differences in yield between infected area and uninfected area, it was found that, the weed infestation caused a loss of about 320 kg/feddan, 87.2 kg/ton, at a rate of about 8.7% of feddan yield, diseases infestation caused a loss of about 390 kg/feddan, 106.3 kg/ton, at a rate of about 10.6% of feddan yield, and pests infestation caused a loss of about 90 kg/feddan, 24.5 kg/ton, at a rate of about 2.5% of feddan yield.

The percentage of infected areas in the sample was calculated from the data contained in table 6 and the results are tabulated in the table 7. These percentages were about, 89% for weed infestation, 27% for disease infestation and 22% for pest infestation.

By generalizing those estimated percentages for the whole rice area in the governorate, results in table 7 show that the infected area by weeds, diseases and pest in the governorate were about 327.4, 98.7 and 80.3 thousand feddans respictively.

According to what was previously explained in the research method, the losses due to infection of weeds, diseases and pests in the sample were estimated at about 0.32, 0.39 and 0.09 ton/feddan respectively.

Table 7 indicates that the rice losses for the whole governorate due to infection of weeds, diseases and pests were estimated at about 104.8, 38.5, 7.2 thousand tons respectively, with a total of about 150.5 thousand tons, at a rate of about 10.7% of the governorate's total production of rice, at value of 40.2 million dollars, equivalent to about 669.5 million L.E.

2.2- Estimating the quantitative losses of rice during harvest:

In Egypt, rice harvesting is carried out in two common ways: a- Manual harvesting, which includes manual harvest after the crop has matured, then it is tied up into small bundles of harvested straw and left for about ten days during which the bundles are constantly flipping to dry the crop. Then the crop is collected in stacks and the threshing and winnowing processes is carried out. b- Machinery harvesting, as combine is used to carry out both harvesting, threshing and winnowing processes.

Table 8 indicates that the ratio of manual harvesting users in the sample was about 15% of the total sample farmers, while the ratio of machinery harvesting users was about 85%. The amount of loss using manual harvesting was about 108 kg / feddan, 29.4 kg / ton, at a rate of about 2.9% of the yield. In items of harvesting operations, the loss during harvesting, binding and flipping was about 69.4 kg/feddan, 18.9 kg/ton, during stacking was about 6.4 kg/feddan, 1.7 kg/ton, during threshing and winnowing was about 32.2 kg/feddan, 8.8 kg ton. For machinery harvesting, the loss was about 74.5 kg / feddan, 20.3 kg/ton, at a rate of about 2% of the yield.

Table 7: Estimating the quantitative production losses of rice due to infection of diseases, pests and weeds in Dakahlia Governorate.

Infection	percentage of the area in the sample %	Area in the governorate thousand feddan*	Amount of the loss in the sample kg/ feddan	Amount of the loss in the governorate thousand ton**	Value of the loss in the governorate million $	Value of the loss in the governorate million L.E.
weeds	0.89	327.4	0.320	104.8	28.0	466.0
diseases	0.27	98.7	0.390	38.5	10.3	171.3
pests	0.22	80.3	0.090	7.2	1.9	32.2
total				150.51	40.2	669.5

*Infected area in the governorate = The percentage of rice infected area in the sample x total rice area in the governorate.

**Amount of loss in the governorate= Amount of rice loss in the sample per feddan x Infected area in the governorate.

Source: calculated from Table 6.

Table 8: the quantitative production losses of rice during harvest in Dakahlia Governorate.

procsess		Number of observations and its proportion for the total sample	Area and its proportion for the total sample	Amount of the loss kg/ feddan	Amount of the loss kg/ ton	% of the yield
Manual harvesting	harvesting,binding and flipping	12 (15%)	17.3 (11.4%)	69	18.9	1.9
	stacking			6.4	1.7	0.17
	threshing and winnowing			32.2	8.8	0.9
	total			108	29.4	2.9
Machinery harvesting (Combine)		68 (85%)	82.7 (88.6%)	74.5	20.3	2

Source: Collected and calculated from the primary data, season 2019.

As was done previously, the area of rice that used manual harvesting and that used machinery harvesting were calculated for the whole governorate. Table 9 indicates that, they were estimated at about 41.9, 326.9 thousand feddans respectively, the losses during harvesting in the sample were estimated at about 0.108 and 0.08 tons/feddan for the two techniques of harvesting respectively, the amount of rice losses during harvesting were estimated for the whole governorate estimated at 4.5 and 24.5 thousand tons respectively , with a total of about 29 thousand tons, at a rate of about 2.06% of the governorate's total production of rice, at value of 7.8 million dollars, equivalent to about 129.2 million L.E.

Table 9: Estimating the quantitative production losses of rice during harvest in Dakahlia Governorate.

Harvesting method	Percentage of area in the sample %	Area in the governorate thousand feddan	Amount of the loss in the sample kg/ feddan	Amount of the loss in the governorate thousand ton	Value of the loss in the governorate million $	Value of loss in the governorate million L.E.
Manual	0.11	41.9	0.108	4.52	1.2	20.1
Machinery	0.89	326.9	0.075	24.52	6.6	109.1
Total		368.8		29.0	7.8	129.2

Source: calculated from Table 8.

The results of the questionnaire show that, the availability of family work, the small size of farm holdings and the high percentage of moisture of the machinery harvested crop were the constraints of using machinery harvesting of rice crop.

2.3- Total quantitative production losses of rice in Dakahlia governorate.

From the previous, the total quantitative production loss was calculated for the whole governorate at table 10, which amounted at about 327.5 thousand tons, at about 23.3% of the governorate's total production of rice, Its value was about 87.5 million dollars, equivalent to about 1456.9 million L.E, to which the losses due to not adopting recommended techniques, infection of diseases, pests and weeds

and during harvest contributed by 45.2%, 46%, 8.9% respectively.

Table (10): Total quantitative production losses of rice in Dakahlia governorate.

Losses due to	amount of total Quantitative production loss		Value of the loss in the governorate million $	Value of loss in the governorate million L.E.
	Amount thousand ton	% of the total		
not adopting recommended techniques	147.98	45.2	39.5	658.2
infection of diseases, pests and weeds	150.51	46.0	40.2	669.5
during harvest	29.04	8.9	7.8	129.2
Total	327.53	100.0	87.5	1456.9

Source: calculated from Tables 5,7 and 9.

3- Estimating the quantitative marketing losses of rice in Dakahlia governorate.

This section deals with the Estimation of rice marketing losses, viz. amount lost at different stages of crop marketing i.e. packing, handling, transportation, storage and processing the crop.

3.1- The marketing practice of rice in Dakahlia governorate.

According to the questionnaire that was conducted in this regard, about 22% of the crop was stored by the farmer for home consumption and about 30% of the crop was marketed by the farmer, while about 48% of the crop was marketed by intermediaries, with a total market share of about 78%.

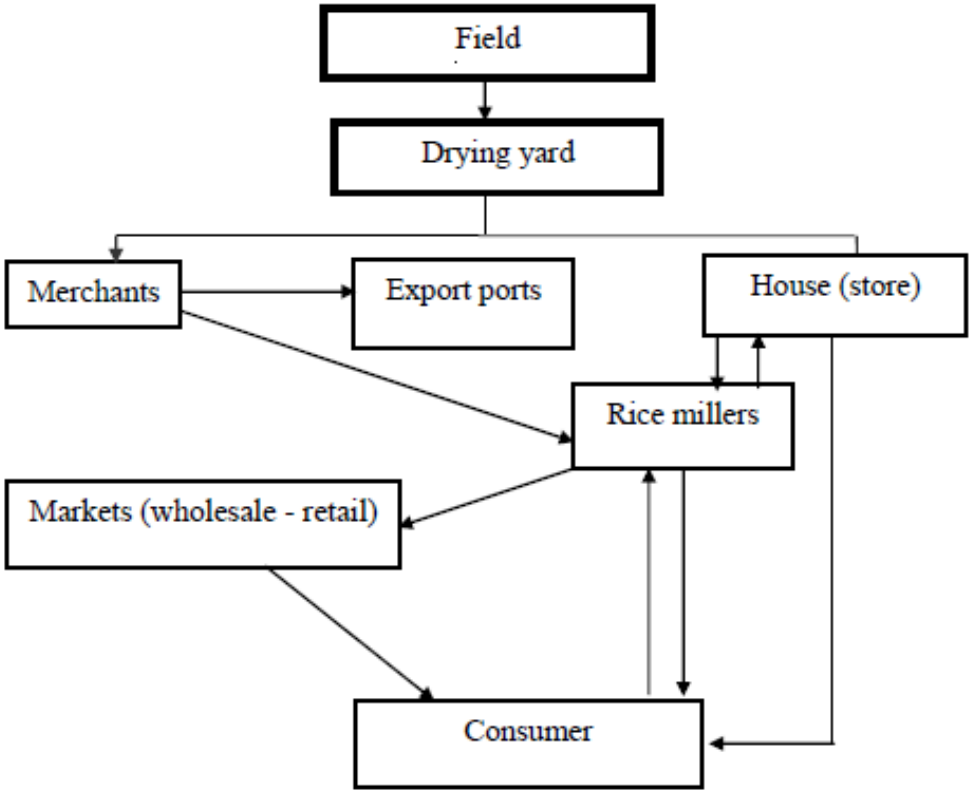

Figure 1: The marketing practice of rice in Dakahlia Governorate.
Source: primary data, season 2019.

The figure 1 shows the marketing practice and channels of rice. The figure shows that the crop was transported from the field to a well-ventilated yard to dry it, after drying the crop's marketing channels were numerous according to the following:

a- From drying yard to the home, a part of it was stored for processing by rice millers for consumption and the remaining was marketed either to other consumers or to rice millers to processing it and marketed it to the consumer, and this channel was about 52% of rice produced.

b- From drying yard to the merchants (stores) then, to the export ports, or to the rice millers and then to the markets (wholesale-retail) for sale to the consumer, and this channel was about 48% of the rice produced.

3.2- Estimating the quantitative marketing losses of rice

3.2.1- Estimating the quantitative marketing loss of rice during packing.

The results of the questionnaire showed that no loss of rice was recorded during packing, this is due to the fact that farmers (or processors) used a plastic sheet under the packages to prevent loss.

3.2.2- Estimating the quantitative marketing loss of rice during transportation.

The rice crop transportation loss was followed up during different marketing stages and the observations were recorded in table 11. The measured loss of the rice crop during transportation was about 5.1 kg/ ton. In detail, the transportation loss of the crop from the field to the drying yard measured at 1.4 kg / ton, at a rate of 27.5% of the total transportation loss, from the drying yard to the house (store) measured at 1.2 kg/ton, at a rate of 23.5%, from the drying yard to the merchants (store) measured at 1.4 kg/ton, at a rate of 27.5%, from store to the rice millers measured at 1.1 kg/ton, at a rate of 21.6%, while no loss of rice was recorded from the rice millers to retailer sale and consumer.

Table 11: The quantitative marketing loss of rice during transportation.

From	To	Amount of the loss k.g/ton	% of the total
Field	Drying yard	1.4	27.5
Drying yard	The house (store)	1.2	23.5
Drying yard	Merchants (store)	1.4	27.5
store	Rice millers	1.1	21.6
Rice millers	Retailer , consumer	0.0	0.0
Total		5.1	100.0

Source: Collected and calculated from the primary data, season 2019.

3.2.3- Estimating the quantitative marketing loss of rice during storage.

Literature have reported that, greatest post-harvest losses occur at the storage stage, storage loss may be initiated at the farm level, trader level, retailer level or government warehouse level and may be caused by insects, mites, rodents and micro-organisms (7). Three modes of storage were observed in the sample (a) Closed warehouses, (b) covered warehouses, (c) open warehouses. Storage loss of rice estimated by the difference of weight of rice before and after storage (for a period 4-5 months) and the observations were recorded in table 12. Table 12 indicates that the amount of storage loss measured at, 17.1 kg/ton for closed warehouses mode, 21.3 kg/ton for covered warehouses mode, 23.5 kg/ton for open warehouses mode, with average for all the sample at about 20.6 kg/ton.

Table 12: The quantitative marketing loss of rice during storage.

Storage mode	Loss amount kg/ton
closed warehouses	17.1
covered warehouses	21.3
open warehouses	23.5
average	20.6

Source: Collected and calculated from the primary data, season 2019

3.2.4- Estimating the quantitative marketing loss of rice during processing.

Rice is obtained by husking paddy through the processes of pre-cleaning, hulling, husk separation, par-boiling, polishing and glazing. Grains may be broken during these processes. The extract rate refers to the amount of rice processed from one ton of paddy, it measured at the sample at about 66% . The processing loss included broken rice grains which was estimated at about 3.8% of the weight of rice processed, at about 38 kg /ton of paddy.

3.2.5- Estimating the total quantitative marketing losses of rice in Dakahlia governorate.

By generalizing the sample estimates of transportation, storage and processing losses for the study population, Dakahlia governorate, the whole governorate's marketing losses of rice were estimated. Table 13 show that it amounted to about 89.5 thousand tons, with a value of about 23.9 million dollars, equivalent to about 398.1 million L.E.

Transportation loss, storage loss and processing loss contributed by about 8%, 32.3%, 59.7% respectively.

Table 13: Total quantitative marketing losses of rice in Dakahlia Governorate.

stage	Amount of the loss in the sample kg/ ton	Amount of the loss in the governorate thousand ton*	% of the total	Value of the loss in the governorate million $	Value of loss in the governorate million L.E.
transportation	5.1	7.2	8.0	1.9	31.9
storage	20.6	28.9	32.3	7.7	128.7
processing	38.0	53.4	59.7	14.3	237.5
total	63.7	89.5	100.0	23.9	398.1

*Amount of the loss in the governorate = Amount of the loss in the sample x total production of rice in the governorate.
Source: calculated from tables 11 and 12.

4- Estimating the quantitative Consumption losses of rice in Dakahlia governorate.

The present study was concerned with studying the part of the consumption loss related to the unused residue of rice prepared for consumption (cooked), it was estimated by measuring the percentage of wastage of the remaining unused rice from the total weight of the rice prepared for consumption (cooked). Accordingly, consumption loss was estimated at about 6.3% of the total weight of cooked rice, at about 63 kg/ton. By generalizing this estimate for the available amount of rice for consumption in study population, Dakahlia governorate, after excluding the previously estimated marketing loss, the whole governorate's consumption loss of rice was estimated at 82.9 thousand tons, with a value of about 22.1 million dollars, equivalent to about 368.6 million L.E.

5- The total quantitative loss of rice in Dakahlia governorate.

From the above, by aggregating the quantitative production, marketing and consumption losses, previously estimated, the total quantitative loss of rice in Dakahlia governorate was estimated. Table 14 indicates that the loss amounted to about 499.9 thousand tons, with a value of about 133.5 million dollars, equivalent to about 2223.6 million L.E. production loss, marketing loss and consumption loss contributed by about 65.5%, 17.9%, 16.6% respectively.

Table 14: The total quantitative loss of rice in Dakahlia Governorate.

quantitative loss	Amount of the loss in the governorate thousand ton(1)	% of the total	Value of the loss in the governorate million $	Value of loss in the governorate million L.E.
production loss	327.5	65.5	87.5	1456.9
marketing loss	89.5	17.9	23.9	398.1
consumption loss	82.9	16.6	22.1	368.6
total loss	499.9	100.0	133.5	2223.6

Source: calculated from tables 10 and 13.

6- Study of rice loss as one of the axes of Egyptian water security:

The annual availability of water in Egypt is relatively stable, at about 66.2 billion m3. The relative stability in this resource along with the increasing population growth has led to the annual decrease in the per capita share of water at about 680 m3 in 2019. In this context, rationalizing water and increasing the efficiency of its use is a major goal of the sustainable development strategy in Egypt. For Dakahlia governorate, rice is the greatest consumer of irrigation water in 2019, as it consumed about 71% of the amount of water used for summer cultivation in Dakahlia governorate (13). The current study focused on studying the loss as one of the ways of rationalizing the water use, by estimating the amount of water loss as an estimate of the amount of rice loss. Table 15 shows that, the average amount of water consumed per feddan of rice measured in the sample at about 7200 m3. the yield of rice amounted in the sample at about 3.67 tons/feddan, the average water consumption for producing a ton of rice was estimated at 1961.9 m3, The total loss of irrigation water in the governorate as a result of the rice loss was estimated at 980.7 million m^3.

Table 15: The total loss of irrigation water in Dakahlia governorate due to rice loss.

variable	amount
the average amount of water consumed per feddan (m^3)	7200
the yield (ton)	3.67
the average water consumption for producing a ton (m^3)	1961.9
Amount of rice loss in the governorate (ton)	499.9
The total loss of irrigation water as a result of the rice loss (million m^3)	980.7

Source: Collected and calculated from the primary data, season 2019.

Summary

The research aimed to, estimate the physical and financial losses in rice in Dakahlia governorate, determinate factors responsible for losses and suggest ways to reduce them, and the following results were obtained:

1- The total quantitative production loss of rice for the whole governorate estimated at about 327.5 thousand tons, at rate of about 23.3% of the governorate's total production of rice, at value of 87.5 million dollars, equivalent to about 1456.9 million L.E, to which the losses due to, not adopting recommended techniques, infection of diseases, pests and weeds, during harvest contributed by 45.2% , 46% , 8.9% respectively.
2- The total marketing loss of rice in the governorate estimated at about 89.5 thousand tons, with value of about 23.9 million dollars, equivalent to about 398.1 million L.E., transportation, storage and processing losses contributed by about 8%, 32.3%, 59.7% respectively.
3- The consumption loss of rice was estimated for the whole governorate at 82.9 thousand tons, with a value of about 22.1 million dollars, equivalent to about 368.6 million L.E.
4- The total quantitative loss of rice in Dakahlia governorate was estimated at about 499.9 thousand tons, with a value of about 133.5 million dollars, equivalent to about 2223.6 million L.E., production, marketing and consumption losses contributed by about 65.5%, 17.9%, 16.6% respectively.
5- The total water loss in the governorate as a result of the rice loss was estimated at 980.7 million m^3.

Recommendations to reduce rice losses

1- Activate the extension role and paying attention to raising awareness for farmers towards the application of the recommended techniques in the cultivation of rice crop, especially in terms of using laser leveling, early planting and planting new seeds.
2- There is a need of imparting new training programs to farmers for awareness of the integrated control in the field of disease, pest and weed control, especially biological control.
3- Motivate farmers to use Machinery harvesting as an alternative to manual harvesting.
4- Provide rural agricultural producers with sufficient infrastructure of marketing facilities, transportation, warehouse, rice mills.
5- Raising awareness of the importance of rationalizing consumption.

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