TIMELINESS COSTS IN WHEAT PRODUCTION SYSTEMS

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ABSTRACT

The present study was carried out to design a simulation program based on timeliness of the operations performance for wheat production. Wheat is the most unique of all grain crops in its adaptability to planting in different methods (sowing or drilling, broadcasting and transplanting). The time of harvesting also is changed relative to planting methods consequentially; the quality and the quantity of wheat production may be differ through a harvesting season of bout 30 days. Optimum planting and harvesting operations as well as good timing are needed to minimize the time penalty cost and obtain maximum profits. Timeliness losses due to yield losses are typically expressed as timeliness factors for quantity reduction, in kg ha^{-1}. The results cleared that the correlation coefficients between the mean yield losses and operation starting of the late sowing period ranged from 0.95 to 0.985, compared with 0.92 to 0.97 for the early period. The average time penalty loss for the planting operation were about 411.26$^{\pm}$ 176.60 LE/fed and 427.35$^{\pm}$ 234.17 LE/fed due to a crop being established too early and too late respectively. The best planting date that relating to the highest wheat crop is ranged from 14 to 21 November.

INTRODUCTION

When a field operation is performed there is normally an optimal time for this operation with respect to the value of the crop. If the operation is performed earlier or later, the value of the crop may decrease due to changes in quantity and/or quality (ASABE, 2006).

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Timeliness costs can be described as a time-related penalty decreasing the total revenue in crop production. This penalty, associated with risk, arises when an operation is performed at a non-optimal time or with non-optimal capacity of the equipment, affecting the quality or quantity of a crop (Witney, 1995). Timeliness costs arise in all crop production since it is not possible to operate all crops and fields at the optimal time; nevertheless having high machine capacity can reduce the costs. Generally, timeliness costs are higher in areas with short growth season or high precipitation or both (Lund, 1996). Since these costs are partly dependent on planning and scheduling of the field operation and on machine capacity, they are also referred to as indirect machine costs. If timeliness costs are not considered there is a risk of overall costs and machinery capacity requirements being under-estimated. Significant timeliness costs can occur in regions with short periods available for sowing and harvesting, and since they are affected by the weather such costs are specific for regions and are subject to annual variations (De Toro, 2004). Since the size of the timeliness penalty depends on the capacity of the machine used for the field operation. Increased capacity is associated with higher direct machine investments and decreased labour costs (De Toro & Hansson, 2004a).

Timeliness costs for a specific area or operation are normally calculated using timeliness factors expressing the loss for each day's delay of an operation. Furthermore, timeliness costs are dependent on farm-specific parameters influencing the length of the operation, such as transport distances, labour availability and length of working day. Delays due to weather conditions also affect the length of the operation. When calculating machine capacity, the actual time spent carrying out the operation as well as the time spent on non-productive activities such as turning and adjustment need to be considered (Soerensen, 2003).

Srivastava *et al.* (2006) mention increasing machine capacity as one way to decrease timeliness costs, as larger machines with greater capacity can accomplish more timely work. In addition, optimal work organization and machinery utilization are important in achieving cost reductions (Soerensen, 2003). Another way to decrease timeliness losses is to plant different crops or varieties with different dates of maturation (Nilsson,

1987). On the other hand, in some areas excessive moisture content in the soil prevents seeding operations from starting before the optimum time and consequently the fields are sown as they dry (De Toro A. & Hansson, 2004b). For most harvesting operations, it is not feasible to begin harvesting until the crop is mature (Srivastava *et al.*, 2006). To achieve satisfactory accuracy, particularly in wheat production, it is necessary to calculate timeliness losses in terms of changes in both quantity and quality, since in addition to yield changes, quality parameters such as the nutrient content change with time of harvest and affect the feed value and price of the crop (Witney, 1995). If the machines for harvesting wheat have high capacity, a larger area can be harvested before the rain and consequently the losses can be reduced. Thus, by calculating the value of the wheat at two different harvest times it is possible to determine the timeliness losses at delayed harvest. The result is timeliness factors for wheat harvest, influenced by changes in quantity per feddan that expressed as percentage loss per day (% day^{-1}) where a low value of the timeliness factor is advantageous.

The main purpose of this study was to calculate timeliness factors and subsequent timeliness costs for planting wheat crop. The use of the timeliness factors is exemplified by studying timeliness and machine costs for wheat planting in both of Rice mechanization center (RMC) in Kafr El-Sheikh Governorate and Dakahlia governorate. Finally, the factors influencing the timeliness costs such as planting date season, timeliness coefficients and time penalty cost in LE are analyzed.

MATERIAL AND METHODS

Timeliness Cost Factors

The timeliness cost factors expressed the combined quality and/or quantity reductions occurring due to delayed operations in economic terms, in LE fed^{-1}day^{-1}. In Egypt, the greater of overall yield loss for wheat crop (Sakha 13), the longer of the time span for establishing the crop and at the smaller capacity of the equipment used. The time penalty cost, TC, due to the untimely establishment of a crop is given by the value of the lost yield (Gunnarsson, 2008):

$$T_C = Y_O * Y_L * A * P_c \qquad (1)$$

Where:

T_C = time penalty cost; L.E

Y_o = peak yield; ton/fed.

Y_L = mean yield losses; %

A = crop area; fed.

P_c= crop price; LE/ton

The expected peak crop yield and the optimum date of crop establishment are often known for a particular location. Alternatively, average values which were obtained by further analysis of the experimental dates are presented in table (1) using either the local date or average results, the mean yield losses is computed from the following equation:

$$Y_L = \frac{K_1}{3}(t_0 - t_1)^2 + \frac{K_2}{3}(t_2 - t_0)^2 \qquad (2)$$

Where:

K_1 = early timeliness coefficient

K_2 = late timeliness coefficient

t_0 =optimum sowing day number

t_1 = operation starting day number

t_2 = operation finishing day number

Data Collection Sources

The study was carried out by collecting huge amounts of data and information needed to supply the data base to constrict the program. Crop data were collected from trial results at various farms in Egypt, over the past twenty years from the following locations; Rice mechanization center (RMC) in Kafr El-Sheikh Governorate.

Planting and Harvesting Dates

It has been reported in the literature Rev. that the highest yield of wheat was obtained when it was planted during the third week of November This reported experience was one of the motives for the Egyptian Ministry of Agriculture to recommend that the planting date of wheat must be within the period starting from 1 November and ending by 30 November.

Table (1) Day number, yield, yield losses, K_1 and K_2.

Year	D.N	Yield (ton/Fed)	Yield losses (%)	K_1	K_2	Year	D.N	Yield (ton/Fed)	Yield losses (%)	K_1	K_2
1988	321	2.52	0.00			1998	312	2.535	9.38	0.1955	
	334	2.175	13.69		0.2430		324	2.7975	0.00		
	344	2.13	15.48		0.0878		339	2.4	14.21		0.1895
	354	2.1	16.67		0.0459	1999	312	2.445	19.31	0.4022	
1989	293	2.1225	11.01	0.0344			324	3.03	0.00		
	311	2.22	6.92	0.1228			344	2.37	21.78		0.1634
	324	2.385	0.00			2000	291	2.265	22.56	0.0661	
	334	2.355	1.26		0.0377		309	2.43	16.92	0.2590	
1990	300	2.355	6.27	0.0389			323	2.925	0.00		
	322	2.5125	0.00			2001	324	3.0225	0.00		
	341	2.28	9.25		0.0769		339	2.475	18.11		0.2415
1991	298	2.415	8.78	0.0597			354	2.25	25.56		0.0852
	319	2.6475	0.00			2002	301	2.28	24.53	0.1520	
	333	2.58	2.55		0.0390		323	3.021	0.00		
1992	309	2.46	4.93	0.0875			342	2.4045	20.41		0.1696
	322	2.5875	0.00			2003	278	2.403	16.13	0.0154	
	344	2.4075	6.96		0.0431		319	2.835	1.05	0.0140	
1993	298	2.3025	18.78	0.0834			334	2.865	0.00		
	309	2.415	14.81	0.1975		2004	306	2.505	13.47	0.1579	
	324	2.835	0.00				322	2.895	0.00		
1994	293	2.268	19.14	0.0638			339	2.43	16.06		0.1667
	306	2.445	12.83	0.1332		2005	305	2.475	16.24	0.1904	
	323	2.805	0.00				321	2.955	0.00		
1995	311	2.4255	17.29	0.2305			339	2.445	17.26		0.1598
	326	2.9325	0.00			2006	309	2.55	15.84	0.2112	
	343	2.2695	22.61		0.3461		324	3.03	0.00		
	352	2.19	25.32		0.1436		339	2.5725	15.10		0.0004
1996	311	2.58	12.07	0.2142			354	2.2545	25.59		0.0007
	324	2.934	0.00			2007	305	2.34	22.77	0.2669	
	341	2.4	18.20		0.1889		321	3.03	0.00		
1997	305	2.415	13.90	0.1443			334	2.865	5.45		0.0967
	322	2.805	0.00				349	2.295	24.26		0.0928
	344	2.34	16.58		0.0005						
	354	2.175	22.46		0.0006						
Average (20 years)								2.518		0.145	0.114
SD								±0.266		±0.096	±0.092
CV, %								10.576		66.194	80.636

This period was taken into consideration when designing the mechanization planning program for wheat production in Egypt.

A mathematical approach was used to determine the Program of prediction of machine timeliness costs. It was concentrated on wheat as a model for the intended crop needed to be mechanized due to its importance as a nutritive crop. Because of its sensitivity to environmental conditions and timeliness. The mathematical model was built on Visual Basic program to predict the timeliness cost of wheat production as

presented in Visual Basic program. The flow chart of the proposed model was shown in Fig. (1). While the timeliness coefficient is illustrated in the flow chart presented in Fig. (2). The input data for the mathematical model were represented with their units in Fig. (3).

RESULTS AND DISCUSSION

The Timeliness Coefficients "K_1 and K_2"

The timeliness coefficients "K_1 and K_2" were computed from collected data of 20 years old. That data were drown in Fig. "4". As shown in Fig. (4), it was obvious that increasing the planting season increases the early timeliness coefficients "K_1" until pick point and then comes down. A regression type of polynomial analysis was applied to relate the change in timeliness coefficients "K_1 and K_2" under the effect of planting date "D_n". The obtained regression equations were in the form of:

$$K_1 = 2.0*10^{-8} \ e^{\ 0.0511Dn} \qquad R = 0.62$$

$$K_2 = 1.0 * 10^{13} \ e^{\ 0.097Dn} \qquad R = 0.52$$

where:

$$D_n = planting \ date$$

The timeliness coefficients are listed in table (1) together with standard errors and correlation coefficients. Comparative analytical results for other forms of the yield loss equation achieved high correlation coefficients with the practical result.

The percentage of yield loss

The percentage of yield loss equations with the relevant timeliness coefficients for early and late establishment, K_1 and K_2 respectively, over the time period $(T_2 - T_1)$ which spans the optimum organization date gives the mean percentage of yield loss "Y_L". The "Y_L" losses are illustrated in Fig. 5 and 6 for the collected data over 12 years from (1997 to 2007). The mathematical equation for the data curve introduces same bias in the data analysis.
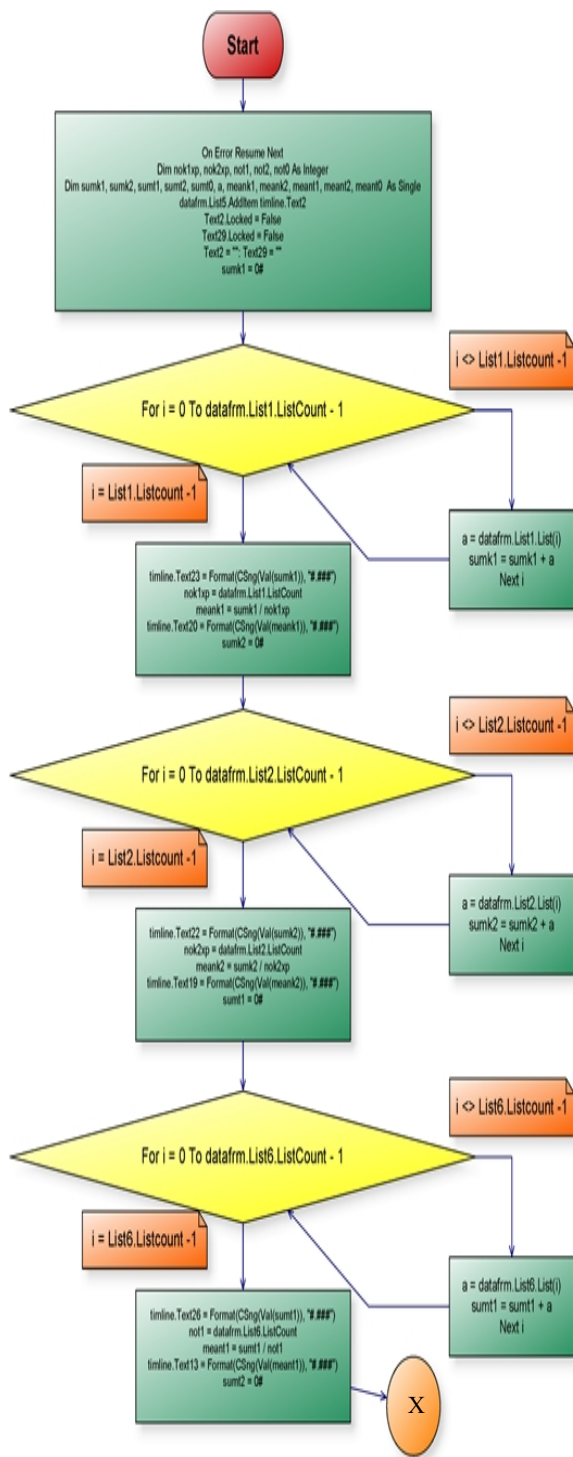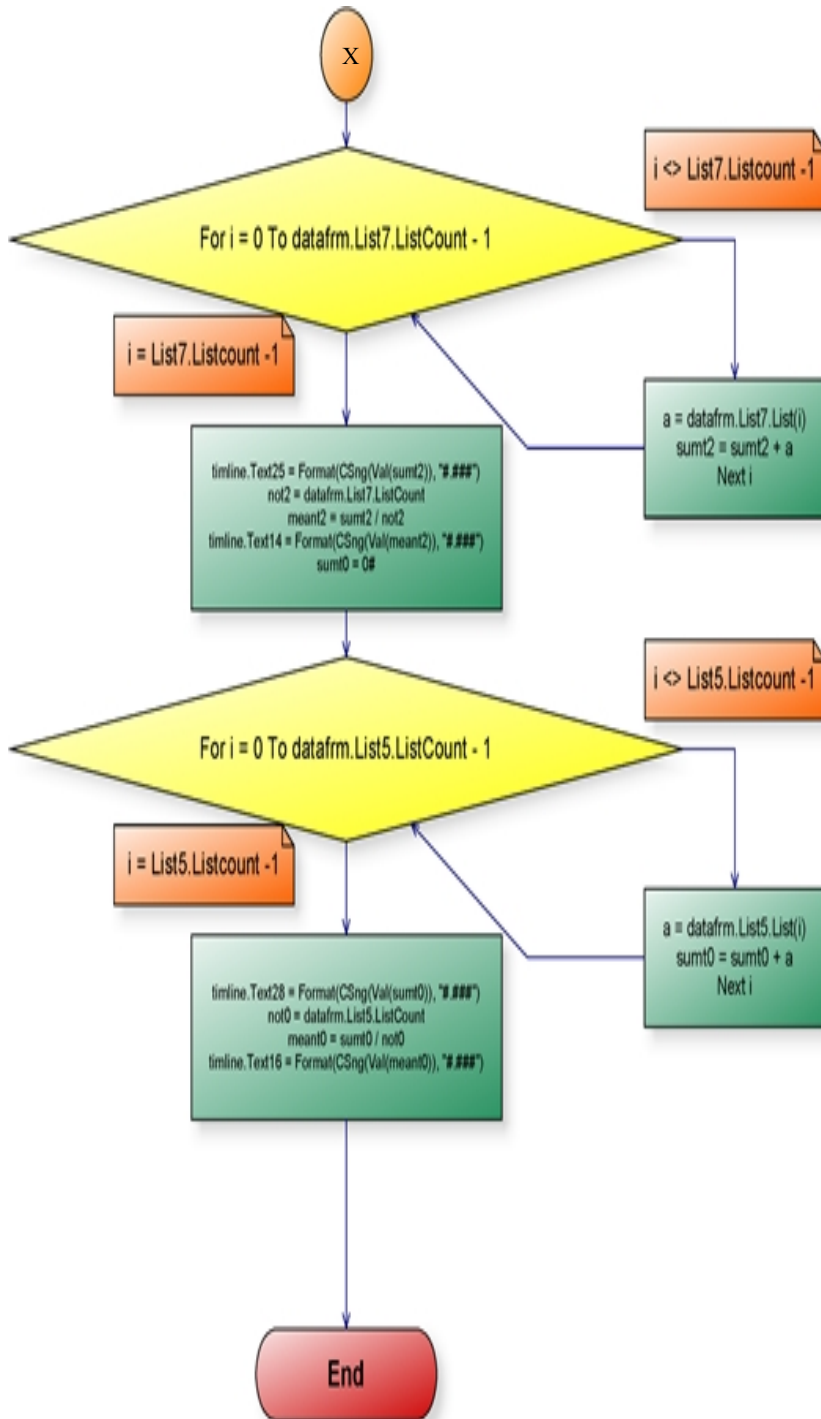
Fig. (1): Flow chart of timeliness-calculation

Con. Fig. (1): Flow chart of timeliness-calculation
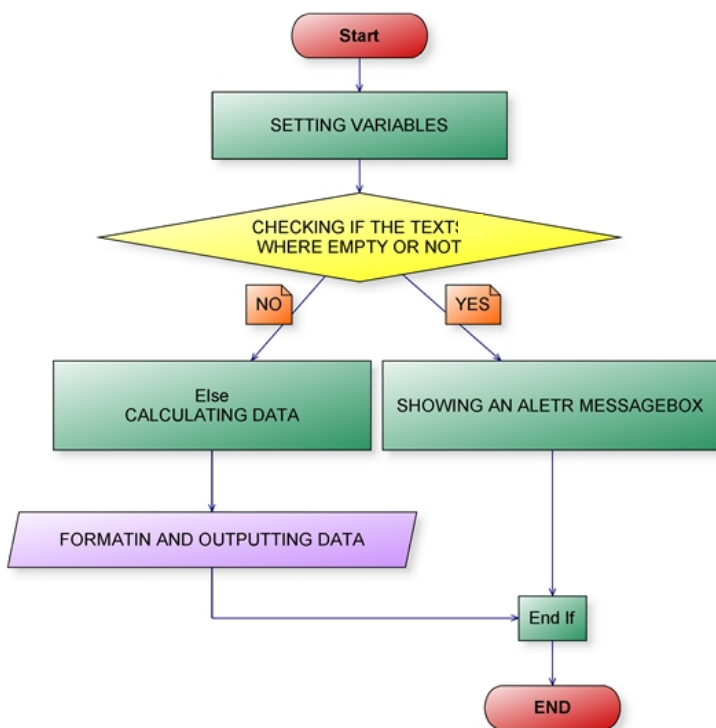
Fig. (2): Flow chart of timeliness coefficient calculate

Fig. (3): Input data and their measuring units for timeliness cost of wheat production as presented in Visual Basic program
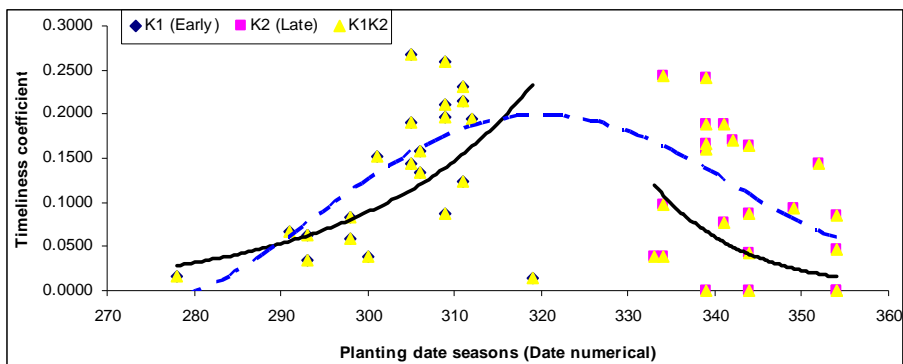
Fig. (4): The timeliness cofficient via planting date

Very high yield losses, of 10% or more, which occur close to the optimum date of crop establishment, gave a questionable validity, less weighing is accorded to these results by constraining the regression curve to the abscissa at optimum date of crop establishment. Equally, the small numbers of date points giving minimal yield losses of only 1% or 2% for very early or very late establishment dates up to 5 weeks from the optimum date are a typical, perhaps because of unusual seasonal conditions, and have only marginal effect on the overall shape of the regression curve. To determine the planting date that recognized the less percentage of "Y_L" the following steps carried out to determine the optimum planting date:-

$$"Y_m" = 0.0351(D_n)^2 - 22.757(D_n) + 3690.4 \quad \text{for the data of Fig. 5}$$

$$\frac{d"Y_m"}{dx} = 2\,(0.0351)\,(D_n) - 22.757$$

$$0 = 2\,(0.0351)\,(D_n) - 22.757$$

Then;

(D_n) = the fit planting date = 325 = 21 days from the short of November.

and

$$"Y_m" = 0.0743(D_n)^2 - 47.253(D_n) + 7514.5 \quad R^2 = 1.0$$

for the data of Fig. 6

Then,

(D_n) = the fit planting date = 317.98 = 14 from November.

Consequently, it may be concluded that the optimum planting date that realizing the highest wheat crop is ranged from 14 to 21 November. The correlation coefficients for the late sowing period ranged from 0.95 to 0.985, compared with 0.92 to 0.97 for the early period. This trend is penalty influenced by the greater volume of data for the early sowing period. Even so, the analysis of early establishment date for sown row crops is particularly variable. It is fortunate, that the accuracy of the analysis is higher for the more critical period in farm scheduling, namely, late sowing.
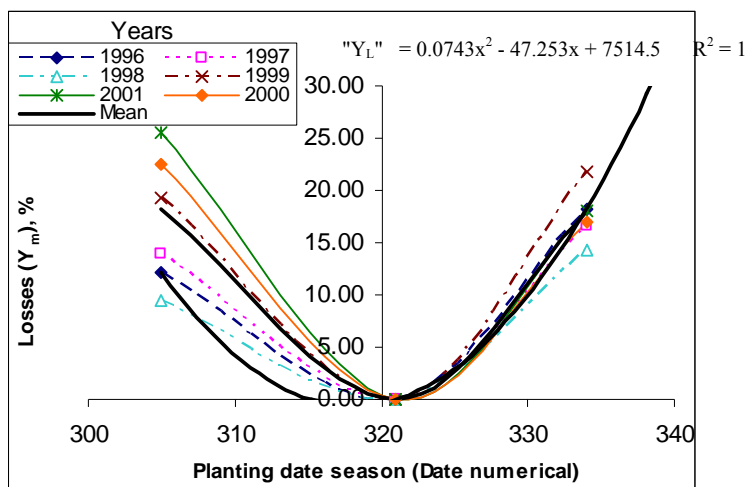

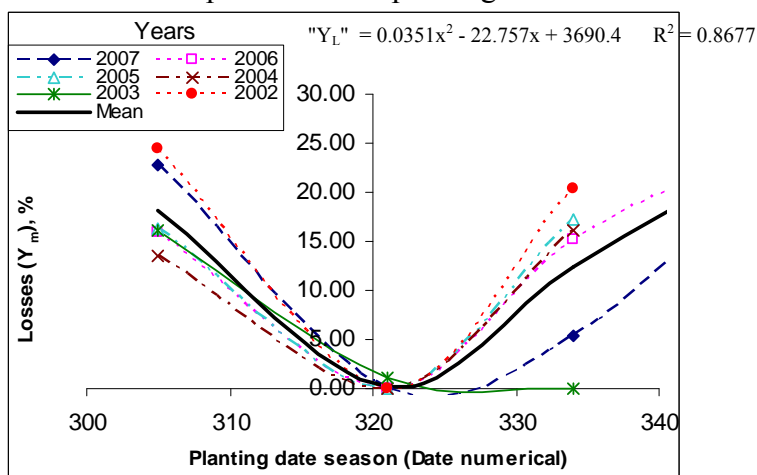Fig. 5: The relationship between the planting wheat date and "Y_L"

Fig. 6: The relationship between the planting wheat date and "Y_L"

A sowing time span carefully chosen to cover the optimum date of establishment can be skewed off-center by a few days of unfavorable weather, placing much more importance on the yield losses for late sowing than for early sowing. For past 20 years, there was better agreement between the predicted and actual yield losses for the early establishment period than for the late sowing period.

The time penalty cost

The penalties of untimely operations which constitute a major element in the economics of farm machinery selection can be expressed as the percentage yield loss, due to a crop being established either too early or too late, against a time scale of the number of days deviation from the optimum date of establishment (Table 1). From the crop establishment data and the simulated in Figs. 5 and 6 the penalty of an untimely planting equation was established by adopting equal time spans before and after the optimum planting date.

By calculating the percentage crop yield loss the timeliness cost can be given by equation "1" and by using the program as shown in Fig. 3. For a given duration of time before and after the optimum planting date (day number of crop establishment) the average and main of crop yield losses for both early and late establishments were given in Figs. from 8 to 10 and Table (2). The average time penalty loss for the planting operation were about $411.26^{\pm} 176.60$ LE/fed and $427.35^{\pm} 234.17$ LE/fed due to a crop

Table (2) The wheat crop penalty cost.

	Penalty Loss LE/Fed		Penalty Loss LE/Fed
	Early	Late	
Average	411.26	427.35	291.27
SD	±176.60	±234.17	±255.26

being established too early and too late respectively. The general in sequence effect for the combination of late and ealy date planting are stablished in Fig. 10.
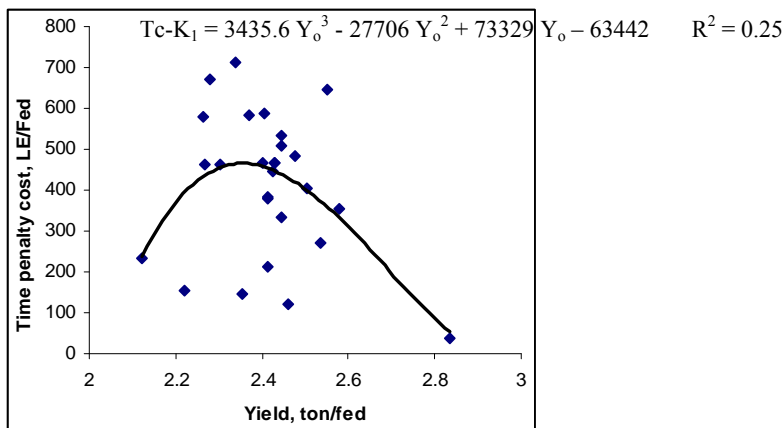
$$Tc\text{-}K_1 = 3435.6\ Y_o^3 - 27706\ Y_o^2 + 73329\ Y_o - 63442 \qquad R^2 = 0.25$$

Fig. (8): Time penalty cost loss due to a crop being established too early

$$Tc\text{-}K_2 = 5195\ Y_o^3 - 39041\ Y_o^2 + 96822\ Y_o - 78879 \qquad R^2 = 0.26$$

Fig. (9): Time penalty cost loss due to a crop being established too late

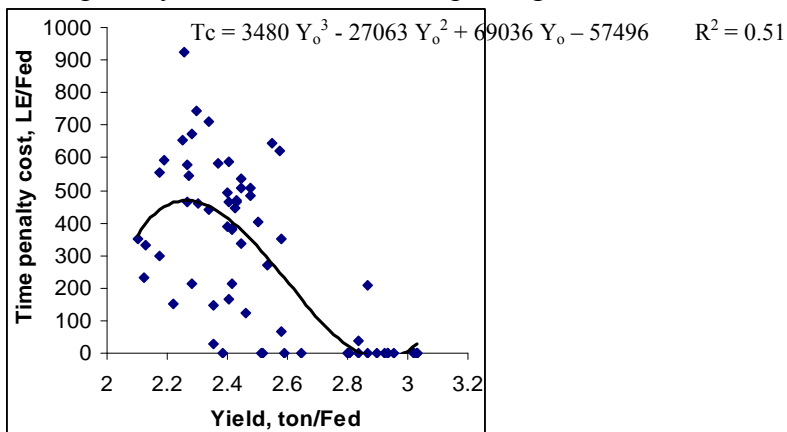$$Tc = 3480\ Y_o^3 - 27063\ Y_o^2 + 69036\ Y_o - 57496 \qquad R^2 = 0.51$$
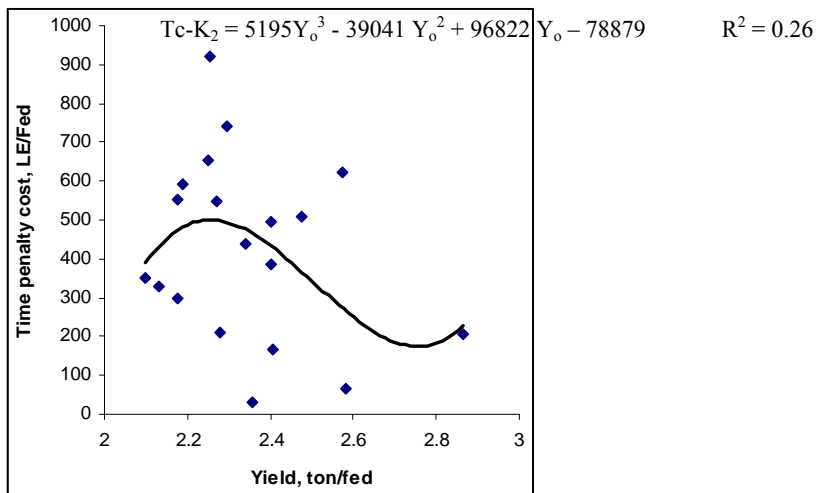
Fig. (10): Time penalty cost loss due to a crop being established too late

The average time penalty loss for the planting operation were about 291.27$^{\pm}$ 255.26 LE/fed (one Fed = 0.42 ha).

CONCLUSIONS

The research can be concluded that:

1- A simulation program based on timeliness of the operations performance for wheat production was identify.

2- The correlation coefficients between the mean yield losses and operation starting of the late sowing period ranged from 0.95 to 0.985, compared with 0.92 to 0.97 for the early period. The average time penalty loss for the planting operation were about 411.26$^{\pm}$ 176.60 LE/fed and 427.35$^{\pm}$ 234.17 LE/fed due to a crop being established too early and too late respectively.

3- The best planting date that relating to the highest wheat crop is ranged from 14 to 21 November

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<u>**الملخص العربى**</u>

الوقت الأمثل لنظم إنتاج القمح

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يهدف البحث برنامج محاكاه يعتمد على الوقت الغير أمثل (Timeliness) لأداء العمليات الزراعية لإنتاج القمح. حيث يعد القمح من محاصيل الحبوب التى يمكن زراعتها بطرق متعددة بذر، تسطير، نثر، وشتل. كذلك يختلف موعد الحصاد تبعاً لطريقة الزراعة. جودة وكمية المحصول تختلف أيضاً بإختلاف موعد الحصاد الذى يمتد حوالى 30 يوم. تحديد الوقت الأمثل لعمليات الزراعة والحصاد هام لتقليل تكاليف إنخفاض المحصول الراجعة لوقت الزراعة والحصول على أعلى عائد. يرجع الفقد فى المحصول إلى فواقد الوقت الأمثل والعوامل المتأثرة به مما يؤثر على كمية المحصول بالكجم/ساعة. توضح النتائج المتحصل عليها من الدراسة أن معامل الإرتباط عند تأخر موعد الزراعة تتراوح بين 0.950 إلى 0.985 مقارنة بـ 0.920 إلى 0.970 عند التبكير فى موعد الزراعة. كما لوحظ أن متوسط الفواقد الراجعة للتبكير والتأخير فى الزراعة كانت 411.26 ± 176.60 و 427.35 ± 234.17 جنيه/ فدان على التوالى. كما وجد أن أفضل وقت للزراعة يحقق أعلى محصول يتراوح بين 14 إلى 21 نوفمبر.

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