EXPERT SYSTEM APPROACH TO ASSIST CANE DELEIVERY SYSTEMS CHOICE

M. N. Awady(1), H. A. Abdel Mawla (2), I. Yehia(3) and A. M. El Lithy(4)

ABSTRACT

The aim of this research is to help in selecting an appropriate cane delivery system for prevailing situations.

The recent paper adds sugar cane transporting systems to the last module of existing Expert System (ES) (FARMEC by Awady et al., 1997) as post harvesting system. The authors were taken among domain experts to evaluate and iterate the degrees of confidence set to assist cane delivery system choice in different situations. The process of iterating results was carried out until its outcome conformed at the end with the experts opinion. "FARMEC E. S." outcomes are accepted for their logical results in different situations. Qualifiers to result in choices were decided to account for vehicle, "camel, cart and trailer combinations" and mill equipment (Narrow-Rail Wagon "NRW", railway wagons and lorries). A total of 14 qualifiers, eight for the first link of transportation and six for the second link, were suggested. Each qualifier was evaluated with one degree. The degrees achieved by any cane delivery system consisted of the sum of the field to store vehicle and that of the store to mill equipment. The main results and recommendations are:

1- *For the 1st. haulage distance (from field to collecting storage), the most appropriate means depend mainly on the distance and road condition. For short and rough roads the cart proved to be best. Meanwhile, for long and good roads, the tractor-drawn trailer hardy proved better than carts.*

---

(1) Prof. Emerit: Ag. Eng., Col. Ag., Ain Shams U.,
(2) Prof., and Head of Ag. Eng. Dept., Al Azhar U., Assiut.,
(3) Senior Res., Ag. Eng. Res. Inst; and
(4) Lecturer, Ag. Eng., Al Azhar U., Assiut.

2- *Camel use is not recommended according to the same argument. However they are expected to continue serving because of their availability on farm for meat, milk, wool, skin, and organic manure production.*
3- *For the second haulage distance (from collecting storage to factory), similarly, the railway has an advantage when rails are available. On other roads large lorry trucks seem to be favorable, followed by other trucks and trailers.*
4- *For the combined 1st. and 2nd haulage, the best of means can be combined. Of course, unloading and loading equipment have to be improved at the junction between two stages. However, tractor trailers might have an advantage if they can continue from the first to second stage without unloading and loading.*

INTRODUCTION

Hansen et al. (1998) stated that long delays between harvesting and milling of sugarcane leads to its deterioration. They developed a simulation model as an appropriate means of analysis conducted on an initial harvesting and transport model of a particular mill and the area supplying. It was concluded that it was necessary to integrate this module with models including limitations in transport, availability, and model of individual farms. These investigations led to greater clarity regarding to various processes in the sugarcane harvesting and delivery systems. A survey of farms that supply the mill has to be conducted and the verified model has to be experimented with to determine methods of reducing delay.

Eggleston et al. (2001) explained that an industrial increase of level of mechanization, lower cane quality is often observed with an increase in trash, however, overall efficiency is normally improved and costs reduced. They conducted intensive studies on the problems of deterioration due to cane delay. The authors highlighted the problems caused by deterioration at different processing stages and recommended to accelerate transport process to reduce delivery delay.

Abdel-Mawla (2000) noted that the duration from the time of cane harvesting to the time of unloading inside the mill may become critical. It has been recommended to deliver cane to the mill in short time because more delay in cane delivery means more losses in sugar production.

Evaluation of cane delivery duration requires large amount of data concerning scheduling, equipment, labor activities and operation conditions of harvesting, loading and transporting.

Systems of cane delivery, in most conditions, have two transport stages. The first is from fields to temporary stores established at the roads, at which the main transport equipment moves. The second is from these stores to mill. Therefore, temporary stores are established at Narrow-Rail (NR) slide lines, railway shipping stations, ports at which cane transport ships land on the Nile, and roads on which other equipment travel.

The transport means of the first stage are:

- A flock of three or four camels, each of average load of 0.3 ton.
- One or more carts of common size used in cane transport of 0.6 ton.
- A trailer of common design pulled by tractor with 3 ton capacity.

The main transport means of the second stage are:

- NR slide wagons 6 - 10 ton load.
- Railway wagons 12 - 14 ton.
- A ship with 6 - 8 compartments each of 6 ton load for cross Nile cane transport (not included in the study).
- Lorries of variable sizes 6 - 18 ton.
- Trailers equipped for cane to mill transport powered by tractors (6 - 10 ton load).

A certain combination of a vehicle of first stage (haulage distance) that delivers the cane to any of the main transport means of the second stage, may represent a cane delivery system. Camels are not considered to deliver cane to the main means if used as repeated trip vehicle (specially large and medium lorries that are loaded on asphalt roads). Such slow transportation means could only be used to handle cane from the fields to the storage the day before loading the lorry. If a quantity of cane has to be harvested in another day before to allow early handling, then a complex delay problem may exist.

Awady et al. (1997) developed an Expert System (ES) named ”FARMEC” to evaluate different Farm-Mechanization Systems. They used an ”ES” shell named ”EXSYSP”. In that work, alternative means are named ”choices”. Elements of preference are named ”qualifiers”. Different choices are credited with weight scores according to domain experts and listed in a

"Decision Table" to result in the preference choices of mechanization means. In general, the same methodology is followed in this recent paper.
Specific qualifiers were suggested for equipment for each transport stage. The sum of scores achieved by equipment in certain combination considers the final score of the system. Score of a delivery system was then computed by assuming some system scores as one hundred. Final decision table was layed down for system selection, system applicability prediction and system expansion explanation.

MATERIALS AND METHODS

Eight qualifiers (methodology of Awady et al., 1997) were suggested for the vehicles of the first haulage distance and six other qualifiers were selected for the equipment of second haulage distance. Weighing scores were decided for each qualifier of the equipment of either first or second stages of transportation, where one score was determined for each qualifier. The sum of both grades of the first and second stages represented the overall score of a cane delivery system. The sum grade of each transport stage was then computed as a percentage of one hundred.

Qualifiers for the first stage means:

1- Field to storage distance: Each of the first link means has score range from zero to 1 according to distance from the field to storage.

2- Road conditions: Camels and carts are able to travel on narrow and rough roads, therefore they were given score 1. Trailers pulled by tractors were given score zero, science they require wide roads.

3- Transport combined with harvesting: This qualifier means the possibility of starting harvesting and transport operations simultaneously, where maximum labor and transport efficiencies may be achieved. Camels and carts were given score of 1 and trailer was given score zero.

4- Delay expected: This qualifier represented delay in the field after harvesting and before loading on the first link means. Both camels and carts were given score 1 and trailer was given score zero.

5- Power availability: Available mechanical power (trailer pulled by tractor) was granted grade 1 and animal power (camels and carts pulled by donkeys) grade zero.

6- Speed: Camel and cart, either in the field or on the road, travel speeds are considered slow, and may be graded zero. Tractor pulled trailer travels much faster and may be graded 1.

7- Load capacity: Transport vehicle load in tons means the quantity of cane the mean can handle and transport in one trip. Since a camel can carry a quantity of cane not more than 0.3 ton and prevailing cart has weight of cane about 0.6 ton, they both were graded zero. The tractor pulled trailer in the first link system may carry about 3.0 tons, therefore was graded 1.

8- Availability of the means: Carts are more available and graded 1. Meanwhile, camels are less available and graded 0.25. Trailers are available for some farmers and graded 0.75.

Qualifiers of the second stage means:

1- Reach distance: The distances at which the main transport vehicles reach with respect to fields. Degrees granted may be as follows:

- **NRWs** move on a special slide track among fields and grade is 0.5
- **Railway shipping stations** have fixed locations at the main railway line, therefore, grade was determined at zero.
- **Lorries** reach depends on lorry size and asphalt roads or width. varied from zero to 0.5.
- **Tractor pulled trailer** can reach off roads or shipped on an asphalt road. Grade varied from zero to 1.

2- Load capacity: Grades granted according to vehicle load are:

- NRW: 0.75.
- Railway wagons: 1.
- Lorries: from 0.25 to 1.
- Equipped trailer: from 0.25 to 0.75.

3- Operation of repeated trip means: This qualifier depends on the means, how far the cane mill is and mill reception conditions. In accordance, grades were as follows:

- Both NRW and railway wagon: grade zero.
- Lorries grade was determined as 1.
- Equipped trailers had grade 1 if the field is close to the mill.

4- Delay control: Large quantity of data should be available to discuss delay and regulations should be taken from both farmer and mill to control

delay by any of operated system. Cane delay is a complex issue and grades were determined as follows:
- NRW transport system: 0.75
- Railway transport system: 0.5.
- Lorry transport system: 0.5
- Equipped trailer transport system: 1.

5- Mechanical loading availability: Certain rules have to be considered under which an economic operation of grab loading exists. For mechanical loading the following grades may be suggested based on the system conformity to the rules:
- NR slide wagons: 0.75.
- Railway wagons: 1.
- Lorries of different sizes: from zero to 1.0.
- Equipped trailer: zero.

6- Used as storage bin: This qualifier considers a utilization of the transport vehicle to maintain 24 hours operation of the mill and grades were:
- NRW transport: 1.
- Railway transport: 1.
- Lorry transport grade: zero.
- Trailer transport system: from 0.4 to 0.5.

Domain Experts: Paper authors, Members of Sugar Crops Research Institute and sugar factory in addition to great sugar farmers are domain experts.

Transport means specifications:

Table 1 and 2 shows transport means specifications for first stage (from field to collecting storage) and second stage (from collecting storage to factory).

Table 1: Transport means specifications for first stage (from field to collecting storage):

Specifications	Camel	Cart	T-trailer
Source of manufacture	Egypt	Egypt	Egypt
Length, cm	450-550	235	400
Width, cm	80	110	200
Height, cm	250-300	100	160
Av. Load, kg	300	800	7100

Table 2: transport means specifications for second stage (from collecting storage to factory):

Specification	NRW[1]		Railway	Trucks		
	Romania	Japan		Small	Medium	Large
Source of manufacture	Romania	Japan	Egypt	USA	England	Germany
Model				Dodge	Thames	Mercides
Power, hp	270	255	255	150	180	250
Length, cm	520	500	600	780	810	760
Width, cm	330	330	180	240	250	240
Height, cm	235	230	120	170	200	170
Av. Load, ton	10	10	13	3	5	12

RESULTS AND DISCUSSION

Decision table for first stage (from field to collecting storage):

Table 3 shows the decision table for first haulage (from field to collecting storage.

Validation cases for first stage (from field to collecting storage):

Table 4 and fig.1 show the validation cases for first haulage (from field to collecting storage).

For the 1st. haulage distance, the most appropriate means depend mainly on the distance and road condition. For short and rough roads (study case 1) the cart proved to be best (score 5.3). Meanwhile, for long and good roads (case 2), the tractor-drawn trailer (score 4.7) hardy proved better than carts (score 4.6).

Camel use is not recommended according to the same figure. However they are expected to continue serving because of their availability on farm for meat, milk, wool, skin, and organic manure production.

Decision table for second stage (from collecting storage to factory):

Table 5 shows the decision table for second haulage (from collecting storage to factory).

Validation cases for second stage (from collecting storage to factory):

Table 6 and fig. 2 show the validation cases of the second haulage (from collecting storage to factory). The railway (score 3.9) has an advantage

when rails are available (third case). On other roads, for first case (distance < 5 km; through field) and second case (distance 15 km; paved road), Large lorry trucks (score 2.6 and 3.6 respectively) seem to be favorable, followed by other trucks (medium trucks score were 2.2 and 3.2 resp. and small trucks scores were 2.1 and 3.1 respectively) and trailers (tractor trailer scores were3.5 and 2.7 respectively).

For the combined 1st. and 2nd haulage, the best of means can be combined. Of course, unloading and loading equipment have to be improved at the junction. However, tractor-trailers might have an advantage if they can continue from the first to second stage without unloading and loading.

Table 3: Decision table.

1st. haulage stage.

(From field to collecting storage)

Choices / Qualifiers	Camel	Cart	T-trailer
Distance:			
< 0.5 km	1.0	0.8	0.5
0.5 – 1.0 km	0.7	0.8	0.7
> 1.0 km	0.4	0.9	1.0
Road conditions:			
Good	-----	-----	-----
Bad	1.0	0.8	0.0
Travel speed:	0.0	0.0	1
Time overlap with harvesting	1.0	1.0	0.5
Field efficiency	1.0	0.7	0.5
Power saving	1.0	0.5	0.0
Load capacity	0.0	0.5	1.0
Availability	0.3	1.0	0.7

Table 4: Validation Cases.

(1st. haulage distance: field to collecting storage.)

1st Case:

Distance: short < 0.5 km.

Road condition: Bad.

Rest of conditions as in table 1.

Choices / Qualifiers	Camel	Cart	T-trailer
Distance:	1.0	0.8	0.5
Road conditions:	1.0	0.8	0.0
Travel speed	0.0	0.0	1.0
Time overlap with harvesting	1.0	1.0	0.5
Field efficiency	0.7	0.7	0.5
Power saving	1.0	0.5	0.0
Load capacity	0.0	0.5	1.0
Availability	0.2	1.0	0.7
∑	**4.9**	**5.3**	**4.2**

2nd Case:

Distance: short > 1.0 km.

Road condition: Good.

Rest of conditions as in table 1.

Choices / Qualifiers	Camel	Cart	T-trailer
Long distance	0.4	0.9	1.0
Good road	---	---	---
Travel speed	0.0	0.0	1.0
Time overlap with harvesting	1.0	1.0	0.5
Field efficiency	0.7	0.7	0.5
Power saving	1.0	0.5	0.0
Load capacity	0.0	0.5	1.0
Availability	0.2	1.0	0.7
∑	**3.3**	**4.6**	**4.7**

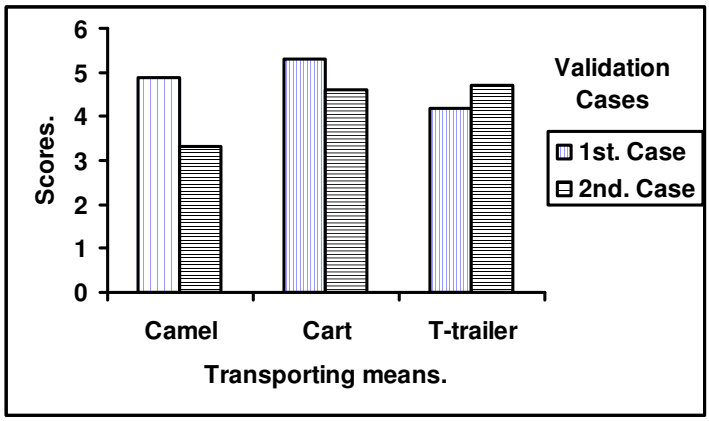

Fig. 1: Case studies for 1st. haulage stage.

Table 5: Decision table. 2nd haulage stage.

(From collecting storage to factory)

Choices / Qualifiers	NRW(1)	Railway	Trucks (2)			Tractor Trailer
			S	M	L	
Distance:						
< 5 km	0.0	0.0	1.0	1.0	1.0	1.0
15 km	0.0	0.0	1.0	1.0	1.0	0.5
Road conditions:						
Through field	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved	0.0	0.0	0.5	0.0	0.0	1.0
Paved	----	----	1.0	1.0	1.0	0.7
Railed	0.7	1.0	----	----	----	----
Time-use-efficiency	0.8 (3)	0.9 (3)	0.8	0.7	0.6	0.7
Load capacity	0.7 (3)	1.0 (3)	0.3	0.5	1.0	0.3
Cane_ Storability	1.0 (3)	1.0 (3)	----	----	----	0.5

(1) Narrow-Rail Wagon.

(2) S, M; L trucks of resp. small, medium; large t-capacity.

(3) Apply only to railed roads.

Table 6: Validation Cases.

2nd haulage distance: collecting storage-factory)

1st Case:

Distance: < 5 km.

Road condition: Through field.

Choices / Qualifiers	NRW	Railway	Trucks			Tractor trailer
			S	M	L	
Distance	0.0	0.0	1.0	1.0	1.0	1.0
Road condition	----	-----	----	----	----	1.0
Time-use-eff.	----		0.8	0.7	0.6	0.7
Load capacity	----		0.3	0.5	1.0	0.3
Cane storability	----	----	----	----	----	0.5
Σ			2.1	2.2	2.6	3.5

2nd. Case:

Distance: 15 km.

Road condition: Paved.

Choices / Qualifiers	NRW	Railway	Trucks			Tractor trailer
			S	M	L	
Distance	----	----	1.0	1.0	1.0	0.5
Road condition	----	-----	1.0	1.0	1.0	0.7
Time-use-eff.	----		0.8	0.7	0.6	0.7
Load capacity	----		0.3	0.5	1.0	0.3
Cane storability	----	----	----	----	----	0.5
Σ			3.1	3.2	3.6	2.7

3r[d]. Case:

Distance: 15 km.

Road condition: Railed with paved parallel.

Choices / Qualifiers	NRW	Railway	Trucks			Tractor trailer
			S	M	L	
Distance	0.0	0.0	1.0	1.0	1.0	0.5
Road condition	0.7	1.0	1.0	1.0	1.0	0.7
Time-use-eff.	0.8	0.9	0.8	0.7	0.6	0.7
Load capacity	0.7	1.0	0.3	0.5	1.0	0.3
Cane storability	1.0	1.0	----	----	----	0.5
Σ	3.2	3.9	3.1	3.2	3.6	2.7

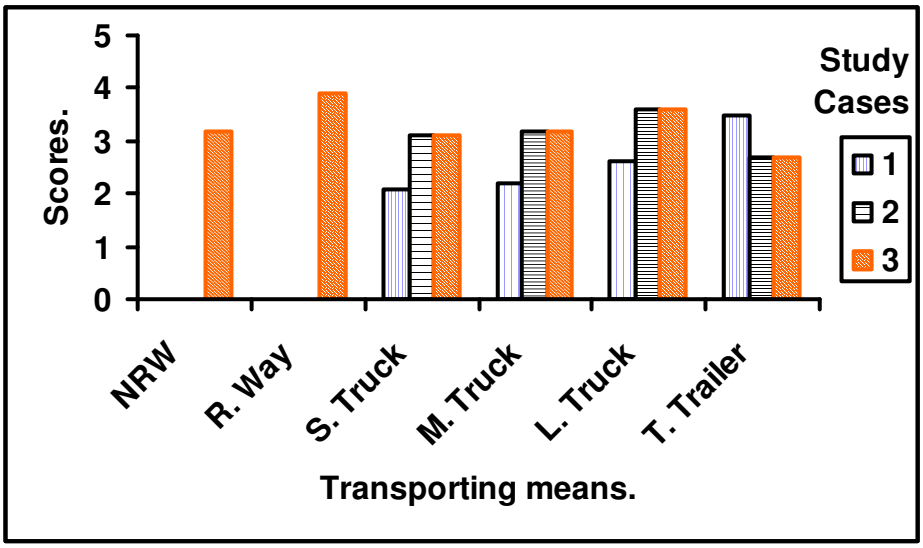

Fig. 2: Case studies for 2nd haulage stage.

CONCLUSION AND RECOMMENDATIONS

1- For the 1[st]. haulage distance (from field to storage), the most appropriate means depend mainly on the distance and road condition. For short and rough roads (study case 1) the cart proved to be best (Fig.

1 shows relative scores). Meanwhile, for long and good roads, the tractor-drawn trailer hardy proved better than carts.

2- Camel use is not recommended according to the same figure. However they are expected to continue serving because of their availability on farm for meat, milk, wool, skin, and organic manure production.

3- For the second haulage distance (from storage to mill), similarly, the railway has an advantage when rails are available (Fig. 2). On other roads large lorry trucks seem to be favorable, followed by other trucks and trailers.

4- For the combined 1st. and 2nd. haulage, the best of means can be combined. Of course, unloading and loading equipment have to be improved at the junction. However, tractor trailers might have an advantage if they can continue from the first to second stage without unloading and loading.

REFERENCES

Awady, M. N., Kabany, A. G., and Attar, M. Z., 1997, Expert-system based selection of farm machinery for Egyptian conditions, 5 th. Conf., MSAE: 121-131.

Abdel-Mawla, H. A., 2000, Analysis of cane delay of traditional delivery systems, 8 th. Conf., MSAE: 25 - 26.

Diaz, L. D. E. C. Ramos, and Sanntiago, A. M., 1994, Cane transport: truck-hauled versus tractor-hauled trains, Sugar-cane, 5: 14-16.

Eggleston G., Logonder, B. and Richard, C., 2001, Effect of harvesting methods and storage time on sugarcane deterioration, Paper considered for ISST: 31-44.

Hansen, A. C., Barnes, A. J. and Lyne, L., 1998, An integrated approach to simulating sugarcane harvest-to-mill delivery systems, ASAE, July: 12-15.

الملخص العربي

أنظمة نقل محصول قصب السكر كخيارات فى برنامج خبير

محمد نبيل العوضى[١]، حسن عبد الرازق عبد المولى[٢]،
إبراهيم يحيى[٣]، أحمد ماهر الليثى[٤]

يسود نظام رئيسى لتوريد القصب للمصنع فى معظم مناطق القصب التابعة لدائرة مصنع معين. وتعتمد النظم التقليدية السائدة على معدات رئيسية يتم تخزينها فى مخازن مؤقته تقع على خطوط حركتها، ويتم نقل القصب الى هذه المخازن بوسائل اخرى عن طريق المزارع. وبناءاً عليه فإن توريد القصب للمصنع يتم تداوله على مرحلتين: المرحلة الاولى من الحقل للمخزن ووسائلها هى الجمال أو عربات الجر(الكارو) أو المقطورة بالجرار، والمرحلة الثانية من المخزن الى المصنع ووسائلها هى عربات الديكوفيل (القضبان الضيقة) وعربات السكة الحديد واللوارى (سيارات النقل) التى ربما تكون نظام النقل الرئيسى فى غياب النظامين الآخرين أو نظام نقل بديل فى حالة وجودهما، و أخيراً مقطورة الجرار المجهزة لتوريد القصب للمصنع. ويمكن لأى نظام نقل أن يتكون من أى وسيلة من وسائل المرحلة الأولى تناول إلى المعدات الرئيسية التى تصل الى المصنع. ولمقارنة نظم توريد القصب من خلال نظام خبير، تم اختيار ثمانية عوامل لمعدات المرحلة الاولى بالإضافة إلى ستة عوامل لمعدات المرحلة الثانية، حيث خصصت لكل عامل درجة واحدة وبجمع درجة وسيلة من المرحلة الاولى مع درجة وسيلة من المرحلة الثانية يتم تقدير النظام، وينسب الى المائة لتوحيد التقدير لجميع الأنظمة فى جدول اتخاذ القرار.

إعتمد تقييم المعدات المناولة على العوامل الهندسية والتشغيلية التالية: المسافة من الحقل للمخزن وطبيعة الطريق الذى تحتاجه المعدة وإمكانية تزامن عمليات الحصاد والنقل وتأخر القصب فى الحقل بعد الحصاد ونوع القدرة التى تعتمد عليه المعدة و سرعة النقل والحمل وتوفر الوسيلة، كما أعتمد تقييم معدات النقل الرئيسية على وصول المعدة بالنسبة للحقل، والحمل وإمكانية تكرار رحلة النقل فى يوم العمل، والتحكم فى تأخر توريد القصب للمصنع، وإمكانية التحميل الآلى للمعدة بالإضافة إلى استخدام المصنع للمعدة لتشوين القصب لتشغيل المصنع على مدار ٢٤ ساعة.

وقد تم اثبات صحة نتائج نظام الخبرة باستشارة خبراء المجال والرجوع إلى المراجع. وقد أعطى كل نظام نقل درجة لكل عنصر من عناصر التقييم. ويدل أعلى مجموع درجات لأى نظام على ملاءمته لمجموعة الظروف الخاصة بحالة الدراسة.

---

(١) أستاذ الهندسة الزراعية المتفرغ بكلية الزراعة جامعة عين شمس،
(٢) أستاذ ورئيس قسم الهندسة الزراعية بكلية الزراعة جامعة الأزهر فرع أسيوط،
(٣) باحث أول، معهد بحوث الهندسة الزراعية،
(٤) مدرس الهندسة الزراعية، كلية الزراعة جامعة الأزهر، فرع أسيوط.

وقد آخذت حالات دراسة متباينة مع وضع الحالات الشاذة والمتطرفة فى الاعتبار لإثبات صحة نظام الخبرة شملت الوسيلة الرئيسية المتاحة وتباين حجمها وكذلك الوسيلة المناولة وظروف الطرق ومسافات النقل للمخازن المؤقتة ثم إلى المصانع. ويمكن تلخيص النتائج فى التالى:

(١) **المرحلة الأولى: النقل من الحقل إلى مخزن التجميع:**

(أ) فى حالة المسافات قصيرة أقل من ٠,٥ كم والطريق غير ممهد: وجد أن أفضل وسيلة نقل هى عربات الجر (الكارو) حيث أعطت أعلى وزن تفضيل ٥,٣، ثم يليها الجمل ٤,٩، ثم المقطورة بالجرار ٤,٢.

(ب) فى حالة المسافات أكبر من ١ كم والطريق جيد: وجد أن أفضل وسيلة نقل هى المقطورة بالجرار حيث أعطت أعلى وزن تفضيل ٤,٧، ثم يليها عربات الجر ٤,٦، ثم الجمل ٣,٣.

(٢) **المرحلة الثانية: النقل من مخزن التجميع إلى المصنع:**

(أ) فى حالة المسافات الأقل من ٥ كم والطريق غير ممهد: وجد أن أفضل وسيلة نقل هى المقطورة بالجرار حيث أعطت أعلى وزن تفضيل ٣,٥، ثم يليها الشاحنات الكبيرة ٢,٦، ثم الشاحنات المتوسطة ٢,٢، ثم الشاحنات الصغيرة ٢,١.

(ب) فى حالة المسافة ١٥ كم والطريق أسفلت: وجد أن أفضل وسيلة نقل هى الشاحنات الكبيرة حيث أعطت أعلى وزن تفضيل ٣,٦، ثم يليها الشاحنات المتوسطة ٣,٢ ثم الصغيرة ٣,١، ثم يليها المقطورة بالجرار ٢,٧.

(ج) فى حالة المسافة ١٥ كم والطريق أسفلت وموازى له خط سكة حديد: وجد أن أفضل وسيلة نقل هى عربات السكة الحديد حيث أعطت أعلى وزن تفضيل ٣,٩، ثم يليها الشاحنات الكبيرة ٣,٦، ثم يليها الشاحنات المتوسطة والقضبان الضيقة (الدكوفيل) بوزن تفضيل ٣,٢، ثم الصغيرة ٣,١، ثم يليها المقطورة بالجرار ٢,٧.

وقد اثبت نظام الخبرة المقدم صحته فى الأحوال المختلفة بما فى ذلك الحالات الشاذة والمتطرفة.