"AGRICULTURAE ENGINEERING ROLE IN REDUCING LOSSES AND MAXMIZING PRODUCTION"
The 11th Annual Conference of Misr Society of Agr. Eng. Oct.2003 : 908 – 922

MINIMIZING THE HARVESTING LOSSES OF THE WHEAT

Dr. A. A. El-Nakib * Dr. Z. Y. Abdel-Lateef*
Dr. A. A. El-Meseery** Eng. A. A. Khattab ***

ABSTRACT

The Kubota Combine (Pro 481) was used as mechanical narvester of wheat (Sakha 69) crop. The grain moisture content was varied at (22.5, 17 and 14%), forward speeds (2.3.27,4.5 and 5.14 km/h) and air fan velocities (6.16, 7.02, 7.66 m/s) The previous factors were studied and evaluate its effects on combine losses.

The main objectives of this study were to determine the optimum operating conditions as time of harvest, forward speed and air fan velocity for adjusting the combine machine to obtain the minimum losses

The results show that:

- The total losses was increased form 2.07% to 2.73% at forward speed 2km/h, and form 4.37% to 5.24% at forward speed 5.14km/h at moisture content from 22.5% to 14% resp.
- The optimum operating harvesting of wheat crop was at combine forward speed 4.5 km/h and grain moisture content of 17.0%.
- The optimum air fan velocity during operating harvesting wheat was 6.16 m/s.

1. INTRODUCTION

Wheat is the most important cereal crop in Egypt as well as in many parts of the world. In Egypt, it occupies about 2.5 millions feddan with a national average of about 2.28 tons, producing yearly about 5.7 million tons of grain, which is very far below the amounts needed for local consumption. Ministry of Agriculture (2000) A.R.E.

Mechanical harvesting is an important in wheat crop production, to use as a new technology to overcome the high cost of traditional harvesting. To reduce losses and costs, combine harvester should be used to minimizing the production losses and low cost.

* Prof. of Agric. Eng., Fac., of Agric. Azhar. Univ.
** lecturer of Agric, Eng., Fac., of Agric. Azhar. Univ.
*** Assist Res. Agric, Eng. Res. Inst. Ministry of Agric.

Kassem *(1995)* studied the effect of some crop and machine parameters on wheat and barely harvesting losses in Saudi Arbia. He reported that cutter par losses increased form 1.1 to 2.1% as the for ward speed increased form 1.0 to 5.0 km/h.

Hassan *et al (1994)* found that increasing forward speed form 2.1 to 3.9 km/h at a constant cutter bar speed of 1.2m/s and constant grain moisture content of 19.2% increased header losses form 0.82% to 1.3 8% from 0.72% to 1.09 % and from 0.22 to 0.87 when using yanmer, Deatz and Fortshirt combines from wheat crops.

Abd El.Mawla (1996) stated that combine harvesters have been developed to increase the combine capability in combining certain crops, to overcome hard conditions of the crops, to facilitate easier maintenance and to increase the overall efficiency of the combine.

Kepner *et al. (1982)* found that seed losses from a combine can occur in connection with any of the four basic operations. These losses are often identified as header, cylinder, walker and shoe losses. Gathering losses in direct combining include heads, pods, or ears, and free seed, lost during the cutting and conveying operations. He stated that threshing effectiveness is related to: Cylinder speed, Cylinder concave clearance, Number of rows concave teeth used with spike tooth cylinder type of crop, The condition of crop in terms of moisture content, maturity etc., and the rate at which the material is fed into the madnine. **Wang** *et al.* (1988) illustrated that at harvesting barley and wheat the separation loss was than 1% for the test combine at material other than grain feed rates below 8 t/h. But when the federate increased to a certain level the loss increased drastically.

The objective of this investigation is to study the factors effect on the mechanical harvesting losses in wheat crop as: forward speed, air fan velocity on shoe loss, grain moisture content, combine performance and costs.

3- MATERIALS AND METHODS

3.1. MATERIALS:

3.1.1. The Combine harvester:

PRO641 Kubota Japanese combine harvester was used, this type of combine is basically designed for rice and it can adept to be suitable for harvesting wheat.

The wheat crop variety of (Shakha 69) was used.

3.2. METHODS:

3.2.1.Experimental procedure:

The experiments were carried out at Hammour village, Damanhor, Behera Governorate province during agricultural seasons 1999-2000 and 2000-2001; the experiments procedure were carried by combine harvester at three different grain moisture content for wheat (22.5, 17 and 14%), at different four forward speeds average (2, 3.27, 4.5 and 5.14 km/h) and at different three air fan velocity average (6.17, 7.03 and 7.67 m/s) respectively, the experimental treatment area was repeated three times. The total experimental area was three feddans.

3.2.2. Grain losses:

3.2.2.1. Pre-harvesting losses measurement:

Pre-harvest losses were determined by locating a wooden frame on the unharvested area and the grain fall on the ground inside were collected. The percentage of preharvest losses was calculated.

3.2.2.2. Header losses measurements:

The header loss was measured by locating a wooden frame of one square meter randomly, where the through put of the combine was previously collected on the canvas-sheet. The pre-harvest losses must be subtracted.

3.2.2.3 Threshing losses measurement:

It could be determined by dragging two canvas sheets behinds the combine, one above other in appropriate positions. The collected materials on the top of canvas sheet consist of straw threshed and unthreshed grains.

The unthreshed ears were separated out, then threshed manually and weighted.

3.2.2.4. Separating losses:

Which represents, the free grain discharged from the drum and ropped into the top of canvas sheet for a distance of 5 meter under ken replicates.

3.2.2.5. Shoe (cleaning) losses:

The collected material from the lower canvas sheet was effected by air fan speed to get the free grain.

3.2.3. Grain moisture content measurement:

The moisture content was measured by using moisture content grain device.

3.2.4. Combine performance efficiency:

$$\text{performance efficiency \%} = \frac{\text{Out put}}{(\text{Output} + \text{Total losses})} \times 100$$

3.2.5. Criterion cost "C" :

The criterion cost of the harvesting operation was estimated using the equation derived by (Awady *et al.*,1982). Cost of harvesting:

RESULTS AND DISCUSSION

The experiments were carried out using Kubota combine as a mechanical harvester of wheat crop. This study was evaluated the losses at different grain moisture content of wheat, different forward speed of combine and different air velocity of fan. Also this study included performance rate of combine, fuel consumption and the cost of harvesting process.

4.1. Combine harvesting losses:

4.1.1. Header loss, "H_L":

The forward speed and grain moisture content had effect on header loss Fig. (4.1) indicate the header loss in wheat crop versus forward speed at different moisture content. The relationships between header losses "HL" and forward speed "S" at different grain moisture content were fitted in the following equation:

$$H_L = a + bs \ldots\ldots (1)$$

where "a" and "b" are equation paramters.

Fig. (4.2) illustrate the relation between parameters "a" and "b" and grain moisture content. (GMC)

The relation between parameters "a" and "b" and moisture

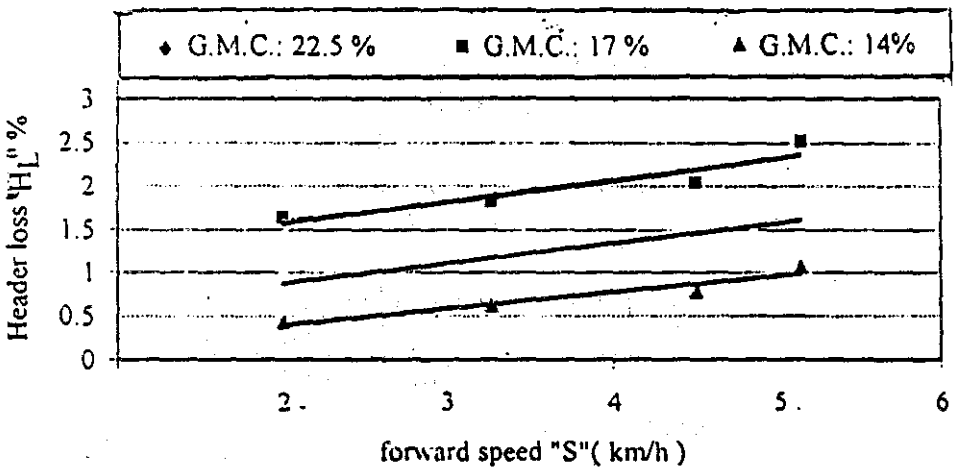

Fig. (4.1): Relation between header losses (H_L) and forward speed (S) at different grain moisture content (G.M.C.) in wheat crop.

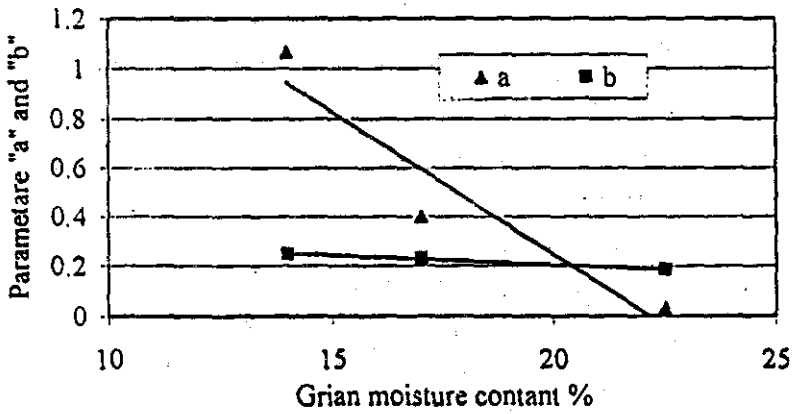

Fig. (4.2): Relation between parameters "a", "b" and moisture content (G.M.C.) header losses (H_L) in wheat crop.

content were:

$$a = -0.115\ GMC + 2.56 \ldots\ldots (2)$$

$$b = 0.007\ GMC + 0.35 \ldots\ldots (3)$$

From equations (2), (3) and (1) the general equation could be expressed as :

$$H_L = GMC\ (-0.115 - 0.007\ S) + 0.35\ S + 2.56 \ldots\ldots (4)$$

4.1.2. Threshing loss "Th_l":

Fig. (4.3) present that the threshing loss in wheat crop versus forward speed at different moisture content.

The relationships between threshing loss "Th_L" and forward speed "S" at different grain moisture content "G.M.C." were fitted in the following equation:

$$Th_L = a + b\ S \ldots\ldots\ldots\ldots (5)$$

where: "a" and "b" are equation parameters.

Fig. (4.4) illustrate the relation between parameters "a" and "b" moisture content "G.M.C.".

The relation between parameters "a" and "b" and grain moisture content "G.M.C." were:

$$a = 0.022\ \ GMC - 0.156 \ldots\ldots\ldots\ldots (6)$$

$$b = 0.01\ \ GMC - 0.0443 \ldots\ldots\ldots\ldots (7)$$

From equation (6), (7) and (5) the general equation could be expressed as:

$$Th_L = 0.022\ GMC + 0.01\ GMC\ S - 0.044\ S - 0.156 \ldots\ldots (14)$$

4.1.3. Separating loss "Sp_L" :

Fig. (4.5) evident that the separating loss in wheat crop versus forward speed at different grain moisture content.

4.1.4. Shoe (cleaning) loss" Sh_L":

Fig. (4.6 a, b, c and d) illustrated that the shoe loss of wheat crop versus forward speed at different grain moisture content, and at different air fan velocity.

4.1.5. Total losses "TL" :

Fig (4.7) demonstrate that the total losses in wheat crop versus forward speed at different moisture content.

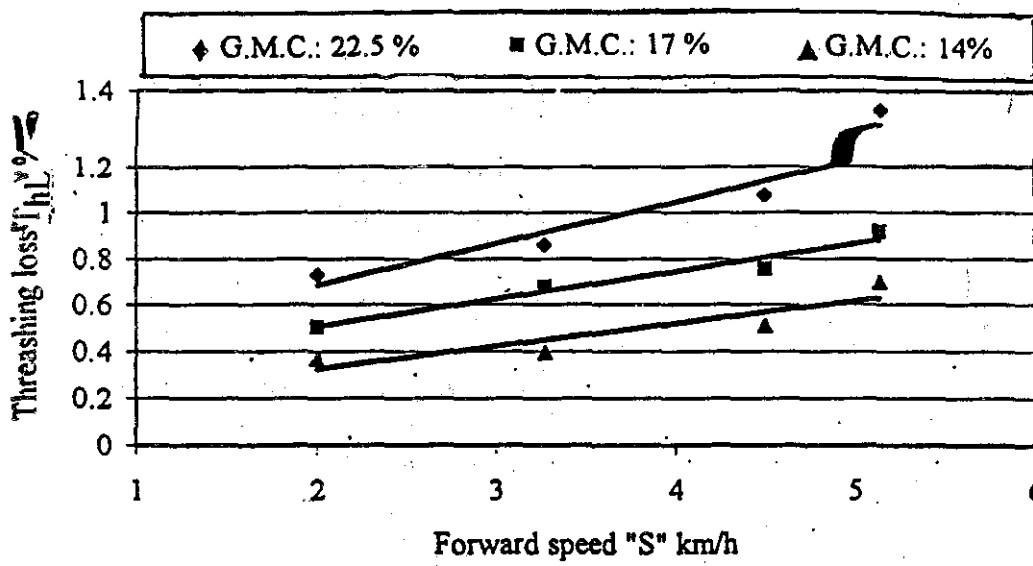

Fig. (4.3): Relation between threshing losses (T_{hl}) and forward speed (S) at different grain moisture content (G.M.C.) in wheat crop.

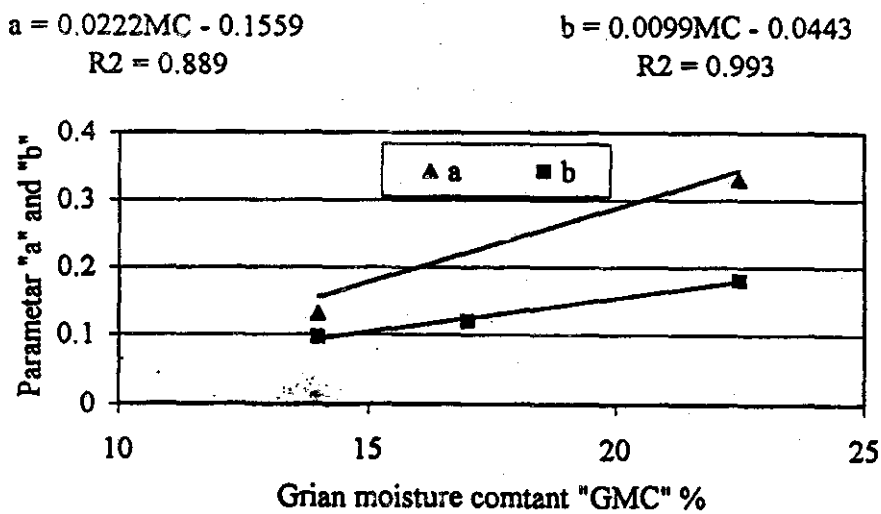

Fig. (4.4): Relation between parameters "a", "b" and grain moisture content (G.M.C.) threshing loss "T_{hl}" in wheat crop.

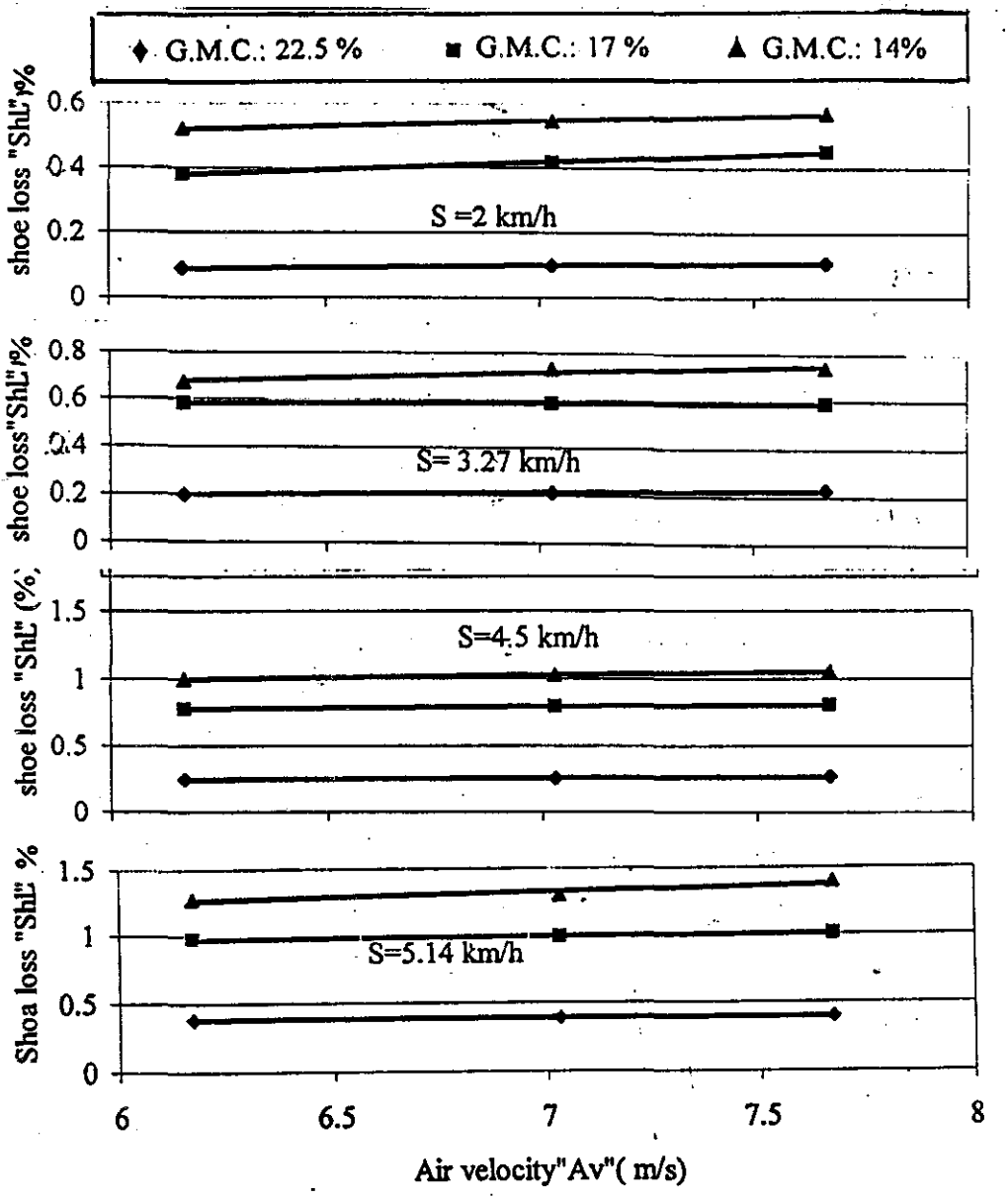

Fig. (4.6) : Relation between shoe losses "S_{hL}" and forward speed "S" at different grain moisture content "G.M.C." and different air fan velocity "A_V" in wheat crop.

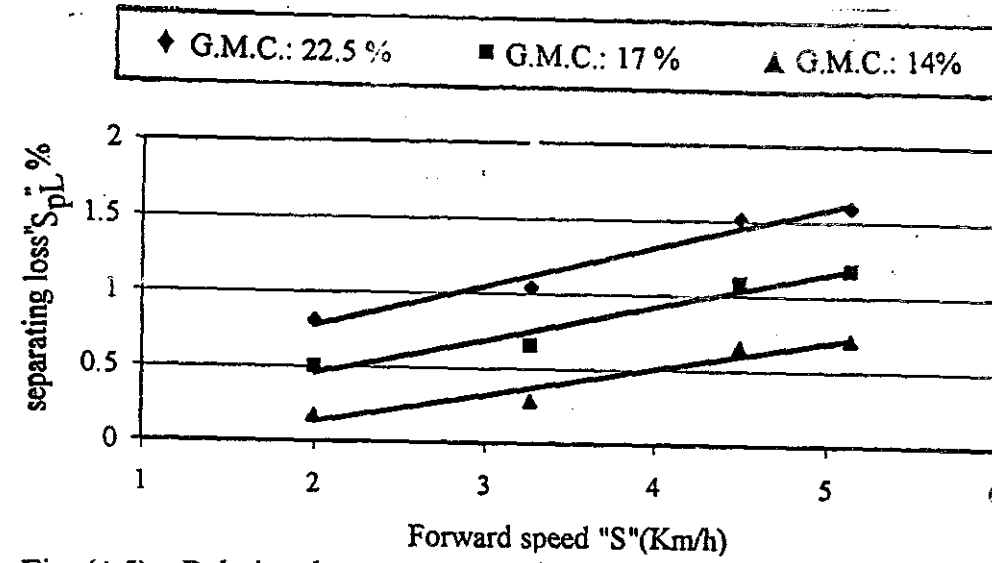

Fig. (4.5): Relation between separating losses (S_{pl}) and forward speed (S) at different grain moisture content (G.M.c.) in wheat crop.

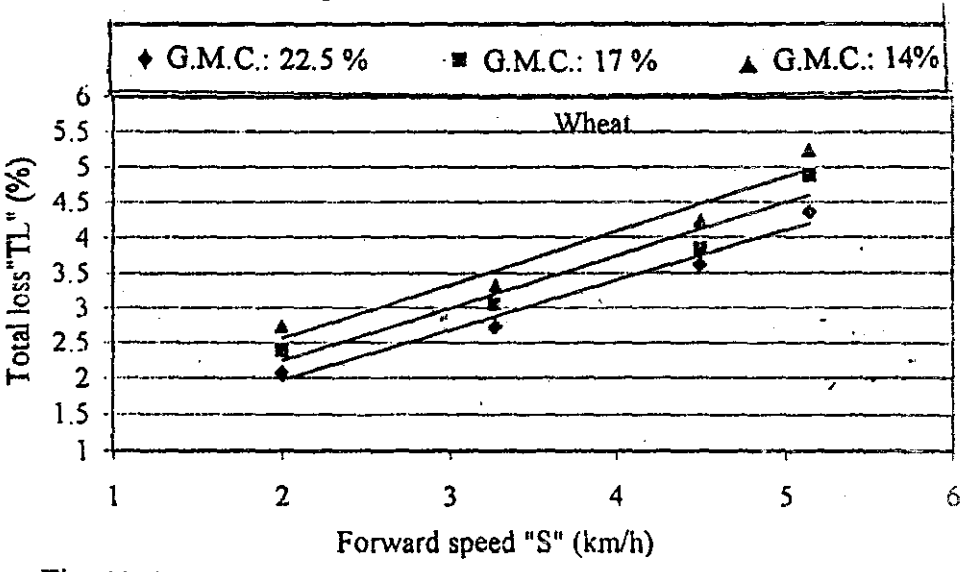

Fig. (4.7): Relatino between parameter "b" and grain moisture content "G.M.C." total loss "T_L" in rice crop.

The reason is due to the exponential increases of all losses of decreasing in grain moisture content and increasing of forward speed.

4.2. Combine performance efficiency "Ce":

The combine performance efficiency decrease with the increasing of the forward speed, at all different grain and straw moisture content.

Fig (4.8) demonstrate the effect of the forward speed, grain moisture content and different straw moisture content on the combine performance efficiency in harvesting wheat crop.

4.3. Machine cost (L.E/fed):

The machine cost of wheat harvesting by combine was considered through using the optimum conditions. The optimum forward speed was 4.5km/h, and the grain moisture content recommended at 17% which was the most suitable one. The equation used to the calculation **(Awady, 1982)** equation.

The results were indicated that the machine cost for wheat about 63.51 LE/fed.

4.4. Criterion cost "C" (L.E/fed):

Fig (4.9) Show the criterion cost in harvesting wheat crop the criterion cost tends to decrease with increasing forward speed. Also the criterion cost was increases from 132.03 to 133.70 L.E/fed, at forward speed 5.14 km/h, at different grain moisture content from 22.5% to 14% this increased depend on increasing of total losses at speed 5.14 km/h and at different grain moisture content.

5. SUMMARY AND CONCLUSION

The objectives of this study were to improve the harvesting process as: decreasing of harvesting losses, determine of forward speed suitable for combine during of harvesting process, determine of air fan velocity for shoe (Cleaning) and defined the moisture content of suitable during harvesting process crop.

- Header losses:

The header loss "H_L" forward speed "S" and grain moisture

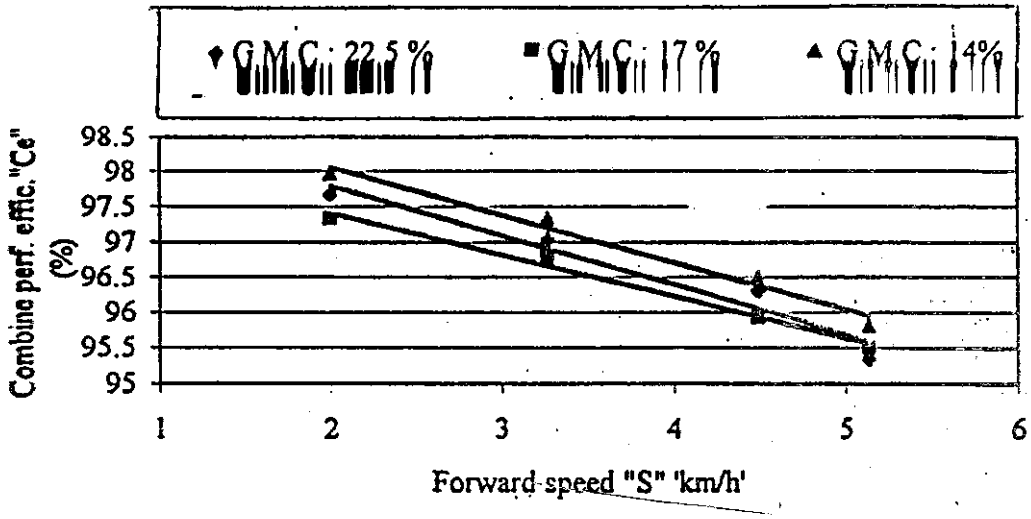

Fig. (4.8): Relation between combine performance efficiency "Ce" and forward speed "S" at grain moisture content "G.M.C." and straw moisture content "S.M.C." in wheat crop.

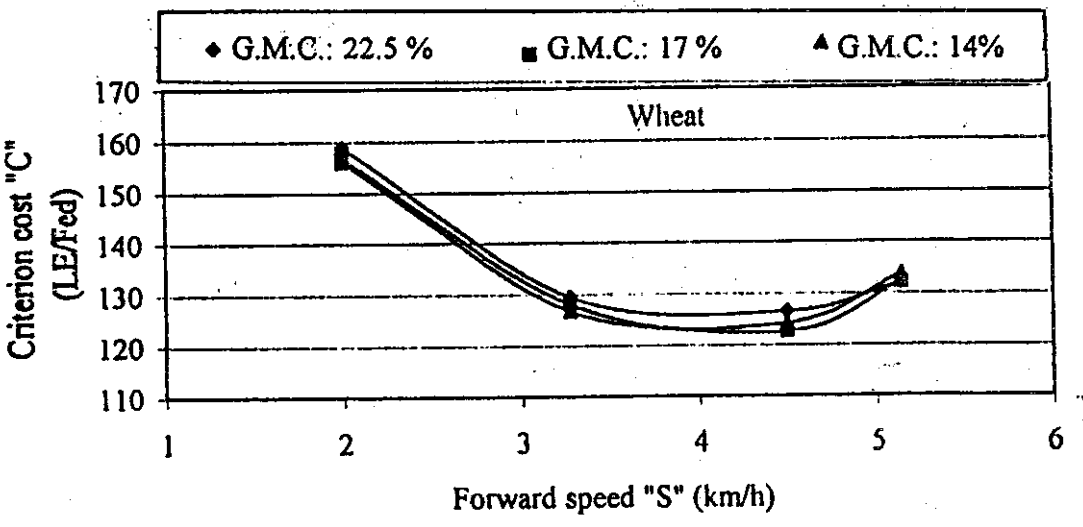

Fig. (4.9): Relation between criterion cost "C" and forward speed "S" at different grain moisture content "G.M.C." and straw moisture content "S.M.C." in wheat crop.

content "GMC" has been involved into from on equation as:

$$H_L = GMC\ (-0.115 - 0.007S) + 0.35S + 2.56$$

- Threshing losses "Th_L":

The threshing loss "Th_L", forward speed "S" and grain moisture content "GMC" has been involved into from the following equation.

$$Th_L = 0.022\ GMC + 0.01\ GMC\ S - 0.044\ S - 0.156$$

- Separating losses "SP_L":

The separating loss decreases with decreased of grain moisture contents at all forward speed from 2.0 to 5.14 km/h, with decreases of grain moisture contents from 22.5 to 14.0%.

- Shoe (cleaning) losses" Sh_L":

The shoe loss increases with increasing of the forward speed from 2.0 to 5.14 km/h, increasing of air fan velocity from 6.17 to 7.67 m/s and decreasing of the grain moisture content from 22.5 to 14.0% for wheat crop.

-The total losses "T_L":

The total loss was increases from 2.38% to 4.88% at increasing of the forward speed from 2 to 5.14 km/h with GMC 17% and it increases from 3.62% to 4.24% at decreasing of GMC from 22.5% to 14% with forward speed 4.5km/h.

- Criterion cost "C":

The criterion cost "C" decreasing from 158.93 LE/fed at "S" 2.0 km/h, and at "GMC" 22.5%, to 132.00 LE/fed at "S" 4.5 km/h, and at "GMC' 14.0% for wheat crop, but it increases at forward speed 5.14 km/h. to 133.68 LE/fed. This increasing may be tents to increased for the total losses cost.

The recommendation:

From the previous results it can be recommended that:

1. The optimum operating harvesting wheat crops was at combine forward speed 4.5 km/h, and grain moisture content 17.0%.
2. The optimum air fan velocity during operating harvesting wheat crops 6.17 m/s.

References

Abd El-Mawla, H.A. (1996). Combine harvesting state of Art. Misr. J.Agric. Eng., 13 (2):440 – 459.

Awady, M.N.; F.Y. Ghoniem and A.I. Hashish (1982). A critical comparison between wheat combine harvesters under Egyptian conditions. Res. B1. No. 1920, Col. Agric. Ain Shams Univ. 13P .

Griffin, C.A. (1976). Fundamentals of machine operations combine harvesting. John Der. Service Publication.

Hassan, M. A.; M.M. Morad; M.A.EL-Shazly and A. Farag (1991). Study on some operating parameters affecting the performance of combine devices with reference to grain losses. Misr J. Agric. Eng., 11 (3): 767 – 780.

Hant, D.R. (1983). Farm power and machinery management. 8th. Ed. Iowa State Univ. Press. Ames. IA.

Kassem, A.S (1995). Effect of some crop and machine parameter on wheat and barley harvesting losses in Saudia Arbia. Misr J. Agric. Eng., 12 (4):866 – 880.

Kepner, R.A.; R. Bainer and E.L. Barger (1982). Principles of farm machinery. 4th. Ed. John W. and Sons, Ins: 381 – 428.

Khattab, A.A (2002) Study of mechanical harvesting losses in wheat and rice crops, M.sc. Agric. Eng. Dept. Faculty of Agric. Al-Azhar Univ.

Sheruddin, B.A., A.I. Kjalil, H.J. Ghulam, and A.K. Ghulam (1991). Influence of timing and date of harvest on wheat grain losses. Agric. Mech. In Asia, Africa and Latin America, 22 (2) : 56-58.

Wange, G.; G.C. Zoerb and L.G. Hill (1988) A combine separation loss monitor. Trans. Of the ASAE, 31 (2); 692-694.

الملخص العربي

** **

تدنية فواقد حصاد القمح

أ.د / عـبد القادر على النقيب[1] أ.د/ زكريا يونس عبد اللطيف[1]
د / علاء الدين على المسيري [1] م / عـوض عـبد الواحـد [2]

أجـريت هـذه الدراسة بواسطة آله الحصاد الجامعة Kupota PRO 481 الياباني الصنع في حصاد محصول القمح (سخا ٦٩) بمنطقة دمنهور محافظة البحيرة خلال موسمي الحصاد (١٩٩٩ – ٢٠٠٠م)، (٢٠٠٠ – ٢٠٠١) .

واشتملت الدراسة على تأثير كلاً من السرعة الأمامية للآلة (٢، ٣,٢٧، ٤,٥، ٥,١٤ كـم / ساعة) والمحتوى الرطوبي للمحصول "GMC" (٢٢,٥، ١٧، ١٤%) وسرعة هواء المروحة اللازمة للتذرية (٦,١٧، ٧,٠٣، ٧,٦٧ م/ث) على فواقد عملية الحصاد (فاقد أمامي، فاقد الدراس، فاقد الفصل، فاقد التنظيف) وكفاءة الآلة والتكاليف الكلية لعملية حصاد القمح.

وكانت النتائج كالآتي:

١- زيـادة السرعة الأمامية من ٢ إلى ٥,١٤ كم/ساعة أدت إلى زيادة الفاقد الأمامي مـن ٠,٤٣% إلـى ٢,٥١% عن تناقص المحتوى الرطوبي من ٢٢,٥% إلى ١٤% وأمكـن ربـط الفقـد الأمامـي "H_L" بالسـرعة الأمامية "S" والمحتوى الرطوبي "GMC" بعلاقة رياضية كالآتي:

$$H_L = 0.115\ GMC + 0.007\ GMC\ (S) + 0.35(S) + 2.56$$

٢- فاقـد الدراس "Th_L": أمكن ربط فاقد الدراس "Th_L" بالسرعة الأمامية "S" والمحتوى الرطوبي "GMC" بعلاقة رياضية كالآتي :

$$Th_L = (0.022\ GMC - 0.01 GMC\ (S) - 0.044(S) - 0.156$$

---

(١) ، (٢) أستاذ ومدرس بقسم الهندسة الزراعية بزراعة الأزهر .

(٣) باحث مساعد بوزارة الزراعة .

٣- **فاقد الفصل "SP_L"** : قل فاقد الفصل بانخفاض المحتوى الرطوبي وانخفاض السرعة من ١,٥% إلى ٠,١٧٥% عند محتوى رطوبي ٢٢,٥ وسرعة ٥,١٤ ومحتوى رطوبي ١٤% وسرعة ٢ كجم / ساعة على الترتيب.

٤- **فاقد التنظيف "Sh_L"** زاد فاقد التنظيف بزيادة السرعة الأمامية للآلة وزيادة سرعة هواء المروحة وانخفاض المحتوى الرطوبي وكان الفاقد يساوي ٠,٠٩ عند سرعة أمامية ٢ كجم / ساعة وسرعة مروحة ٦,١٧ م/ص ومحتوى رطوبي ٢٢,٥% ويساوي ١,٣٩ عند سرعة أمامية ٥,١٤ كم/ث وسرعة مروحة ٧,٧٦ م/ث ومحتوى رطوبي ١٤% .

٥- **الفواقد الكلية "T_L"** : لوحظ زيادة الفاقد الكلي من ٢,٠٧% إلى ٥,٤٢% بزيادة السرعة الأمامية من ٢ إلى ٥,١٤ كم/ساعة وانخفاض المحتوى الرطوبي من ٢٢,٥% إلى ١٤%.

٦- **التكاليف** : تقل التكاليف من ١٥٨,٨٣ إلى ١٢٤,١٣ جنيه للفدان عند زيادة السرعة الأمامية من ٢ إلى ٤,٥ كم/ساعة وانخفاض المحتوى الرطوبي من ٢٢,٥ إلى ١٤% ولكن عند زيادة السرعة الأمامية إلى ٥,١٤ كم/ساعة من ١٣٢ إلى ١٣٣,٦٨ جنيه للفدان وذلك لزيادة قيمة الفاقد الكلي عند هذه السرعة.

التوصيات :

- أنسب تشغيل اقتصادي لمحصول القمح عند سرعة أمامية للآلة ٤,٥ كم / ساعة ومحتوى رطوبي ١٧% حيث أقل تكاليف ١٢٦,٦١ وأدنى فواقد كلية ٠,٧٧%.
- أنسب سرعة هواء للمروحة اللازمة لعملية التذرية ٦,١٧ متر / ث .