Evaluation of Losses on Corn (Zea Mays) Combine Harvester as Effected by Operational Conditions under Khuzestan Climate Condition, Southwest Iran

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Abstract: This research was conducted in order to find the most proper ground speed, feeding rate and cylinder speed of the corn combine harvester. The experiment was set in factorial plan with 3 factors based on a randomized complete block design with 4 replications. Cylinder speed (550, 700, 850 rpm), the feeding rate (150, 200, 250 kg/min) and the ground speed of 2.23, 2.98 and 3.73 km/h were the 3 factors for evaluation. Results indicated that the main effect of the ground speed on header loss, thresher loss and the amount of impurities and shattered kernels were significant at 5%≥P level of probability. With higher ground speeds, since the gathering chain speed was fixed (varies with the speed of the header) the chains didn't have enough time to pull the stalks in, so the stalks were pushed and the ears were knocked off. When the combine ground speed increased, the combine feeding rate also increased and with the certain cylinder speed, the corn ears were not completely threshed and some kernels were left on cobs and also the entering ears numbers into threshing unit were increased. Because of high kernels moisture content (35-40 %) at harvest time, the higher speed of cylinder increased the number of shattered kernels. Ground speed of 2.23 km/h along with the cylinder speed of 550 rpm resulted in maximum grain loss (5%). With the ground speed of 2.98 km/h, The amount of grain on threshed cob and on the ground was the minimum because of balance feeding at this speed of traveling. 3.05 % grain loss with the ground speed of 2.98 km/h and cylinder speed of 550 rpm could be recommended for the place where the experiment was conducted.

Keyword: Corn harvesting, Loss, Combine harvester, Feeding rate

INTRODUCTION
Population will be increased in the world encounter with food shortage and to face with it need to develop production high yield plant such as maize. Maize world planting area third of rank after wheat and rice but of production, has grade one. Mechanization on cereal harvesting, has been an old aim of farmers. The handling of corn is one of the toughest jobs on the farm. For many farmers, it's hard to imagine how corn could be harvested without the sophisticated machinery of today. Combine losses cannot be reduced to zero, but skillful operators can reduce losses to an acceptable level without affecting the rate of combining (Shay, 1993). Knowledge of where grain resides in a combine, cleaning labor requirements, and resulting purity levels would assist producers (Hanna et al., 2007). Separation and cleaning units of harvesters are typically exposed to changing crop and field conditions and are characterized by a highly variable, static process behavior (Maertens et al., 2003).

The aim of harvesting operation, kernels gathering timely and segregate it from harvested crop other sections with minimum losses and maximum quality (Srivastava et al., 1990). To exploit modern combine capacity the machine must be adjusted to the harvesting conditions. Besides the driver's experience, knowledge about the return in quantity and composition is required for targeted combine adjustment. The efficiency of grain separation in a straw walker separator depends on the separating area and the length of time that the crop is in the separator (Reed, 1974; Klenin et al., 1985). A particular challenge to the combine operator will be fields with a large degree of variability. Adjusting the combine for the higher yielding area may result in higher losses in the low yielding area.

Corn harvesting with combine harvester and losses quantity depend on kernel moisture, environment therm degree, field condition (lodged corn), combine harvester (old or new) condition and operator experience. Collection of these factors or one of them can increase or decrease. Studies show that grain loss is exponentially proportional to the rate of flow of material through the combine (Mailander et
The value of reduced grain loss is influenced by the price of grain, the yield of the crop, and the efficiency of threshing and separation (Prentice, 1999). A good combine operator should maintain harvest losses at three to five percent of yield. If losses are greater than this level, the operator should make some combine adjustments to reduce the loss. If the losses are below this range, the crop in the grain tank sometimes has excessive breakage. Studies have shown that losses off the combine can run as high as 20%, even with a properly adjusted machine when it is overloaded. A reasonable loss is considered to be 3% of the total crop or less. Total harvest losses are seldom if ever zero (Anonymous).

MATERIALS AND METHODS

This research was conducted by using a combine harvester (John Deer 955) to measure crop losses at corn harvesting time in Khuzestan province. In each experiment harvesting losses and harvesting losses (platform, thresher and cleaning shoe), broken kernels and impurity percent of kernel were measured. At harvesting time, corn platform was adjusted to pick all corn cobs and kernels. The experiment was conducted in factorial design with 3 levels based on a randomized complete block design with 4 replications. Cylinder speed (550, 700, 850 rpm), the feeding rate (150, 200, 250 kg/min) and the ground speed of 2.23, 2.98 and 3.73 km/h were the different levels of work combination to be evaluated.

By calculation average number of plants in each square meter, average maize weight, determined for feeding rate (kg) should be into the combine harvester per minute, by Equation (1).

Equation (1):

\[
FR=(WE-WH)\times N
\]

FR = Feeding Rate (kg/min)
WE = A maize weight average with husk
WH = a maize husk weight average
N = plant average in square meter

Thus which distance the combine harvester should travel in a minute until that amount of feeding rate (kg/min) into combine calculated by Equation (2).

Equation (2):

\[
L=(N\times D)\div X
\]

L = travel distance (meter)
N = number of ears should into combine in determine feeding rate in a minute
X = number of corn head row (4 row)
D = distance average between two plant on row

Combine harvester should travel this distance in a minute (60 seconds), but for simple calculations 10 meters of distance fixed base, it calculate by Equation (3).

Equation (3):

\[
T=\frac{(t\times D)}{d}
\]

T = Time for 10 meter (seconds)
t = 60 seconds
D = 10 meter
d = travel distance in 60 seconds

Combine harvester should travel only 10 meter in this time, because combine harvester (John Deer 955) the speed was measured manually. Gear range achieved this time and written down of which gear and clutch number to travel.

The kernels that harvested by high moisture content must be dried for safe storage by using Equation (4) for getting maize yield with optimum moisture to be ready for silage.

Equation (4):

\[
W_1=\frac{\left(W_2\times (100-T_1)\right)}{(100-T_2)}
\]

W1 = dry weight (moisture content 14%)
W2 = wet weight
T1 = kernel moisture content at harvest time
T2 = kernel moisture content after drying
RESEARCH RESULTS

Table 1: Result of statistic analysis experiment factors based on kernel breakage, impurity of kernel, cleaning unit loss, Thresher cylinder loss, Platform loss

<table>
<thead>
<tr>
<th>Variation of resources</th>
<th>Degree of freedom</th>
<th>Broken Kernel %</th>
<th>Impurity of kernel %</th>
<th>Cleaning unit loss</th>
<th>Cylinder loss</th>
<th>Platform loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>replication</td>
<td>3</td>
<td>1.37</td>
<td>0.020</td>
<td>0.023</td>
<td>0.45</td>
<td>0.08</td>
</tr>
<tr>
<td>ground speed</td>
<td>2</td>
<td>14.9*</td>
<td>3.29*</td>
<td>0.12 ns</td>
<td>3.38*</td>
<td>1.57*</td>
</tr>
<tr>
<td>cylinder speed</td>
<td>2</td>
<td>9.30</td>
<td>2.16*</td>
<td>0.10 ns</td>
<td>1.68*</td>
<td>0.02 ns</td>
</tr>
<tr>
<td>Cylinder speed × ground speed</td>
<td>4</td>
<td>42.1*</td>
<td>1.85*</td>
<td>0.25 ns</td>
<td>0.07 ns</td>
<td>0.001 ns</td>
</tr>
<tr>
<td>error</td>
<td>24</td>
<td>0.62</td>
<td>0.10</td>
<td>0.12</td>
<td>0.03</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Effect of ground speed on kernel breakage, kernel impurity, cylinder and platform loss was significant, but no significant on cleaning shoe loss. Effect of thresher cylinder rpm rate was significant on kernel breakage, kernel impurity, and cylinder loss but no significant on platform and cleaning unit loss. Interaction between ground speed and thresher cylinder rate was significant on kernel breakage, kernel impurity but no significant on cleaning unit, cylinder and platform loss. Also with increased ground speed and there upon feeding rate was up, in the field that high yield caused overload in gathering unit.

DISCUSSION AND CONCLUSIONS

With rising feeding rate caused of increasing ground speed, passed bulk material between cylinder and concave would be increased. Thus thresher cylinder knocks absorbed by this layer so damage to kernel was decreased and up to increasing ground speed, kernel breakage increased. High cylinder speed was very important reason to damage and crumble corn cobs. By increasing cylinder speed, threshing unit efficiency added for stable ratio feeding rate. In corn combine harvester material other than grain (MOG) was low ratio and only cob passed on straw walker. With in purposes that increase cylinder rate standard limited because more than it caused broken kernel as a result of up to kernel breakage and quality loss.

Observation to Figure (1) that with increase ground speed with increased passed material bulk to thresher unit there upon damage is low. Noticeable kernel thresh criterion in thresher unit and thresher unit efficiency commensurate with knock measure and time that crop will pass of thresher unit.
As regards to Figure (2) maximum kernel tank loss (19.65) happened in 2.23 km/h ground speed and cylinder speed of 550 rpm and minimum loss (8.71) occurred in 2.98 km/h ground speed and cylinder speed of 550 rpm that explanatory in low feeding rate therefore kernel expose to thresher cylinder proximate, kernel extremely stricken fraction (evident and hidden) and decline crop harvested quality too much. Nevertheless by fixing cylinder speed in 550 rpm and increase ground speed from 2.23 to 2.98 km/h kernel quality is upped. In cylinder speed of 700 rpm, reduced process with increase ground speed is observed that illustrative decline kernel tank quality loss and has an optimum and downward slope for kernel tank loss reduction. Regarding cylinder speed of 850 rpm curve can discovered that cylinder high speed have very much broken kernel losses and increasing feeding rate to thresher unit cant compensate that.
Regarding to curve of total kernel fall in Figure (3) can perception by increase feeding rate, total kernel fall increased that consequence of descend thresher unit efficiency and losses in platform. The gist that by increase feeding rate from 150 to 200 kg/min, don’t observation increase tangible in curve slope but from 200 to 250 kg/min and thereafter curve slope very noticeable that explanatory combine harvester efficiency quickly decrease in this feeding rates. Diminution in combine harvester (John Deer 955) efficiency causes thresher unit infirmity of size and length and incoherence between puller chains and roller with higher feeding rate.

Observation Fig (4) by higher feeding rate more than 200 kg/min, total losses curve higher apace and this mainspring for combine harvester (John Deer 955) thresher unit infirmity in higher ground speed. This problem reduced combine harvester capacity, increased period of corn harvesting, increased timeliness cost and increased future planting delay cost exact to farmer.

Pay attention to research result and study of quality and quantitative losses, 3.05 % grain loss with the ground speed of 2.98 km/h and cylinder speed of 550 rpm could be recommended for the place where the experiment was conducted.
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