

INFLUENCE OF SELECTED COMBINE AND CROP PARAMETERS ON KERNEL DAMAGE AND THRESHABILITY OF WHEAT

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This paper reports the effects of combine and crop parameters on wheat recovery (Pak-81). Three levels of each parameters i.e. moisture content, concave clearance and feed rate were selected. Experimental results revealed that doubling the feed rate at constant concave clearance doubled approximately the total grain losses and conversely reduced the breakage of threshed grain by 16%. Grain losses at 26% and 13% moisture content were found higher than those at 19% moisture content at each level of feed rate and concave clearance. Minimum grain loss of 0.94% was found at 19% moisture content, 30 mm concave clearance and 2.82t/hr feed rate. However, minimum grain damage was observed at 26% moisture content, 30mm concave clearance and 5.64t/hr feed rate which was 1.4%. Forward Stepwise Regression Analysis revealed that feed rate was the most important parameter for causing total grain losses and similarly interaction of moisture content and concave clearance resulted in maximum grain damage.

Keywords: Combine; concave clearance; feed rate; regression.

INTRODUCTION

Wheat is an important food crop in Pakistan and is the staple for majority of the world's population (Anonymous, 2004-2005). The world leading country in wheat production is Netherlands giving an average yield of 8122 kg/ha which is two times greater than Pakistan (Anonymous, 2004). Despite the introduction of improved varieties of wheat, better chemical and hydrological inputs, the production is still not enough to feed the present population.

Thus Pakistan's present problem is the augmentation or food supplies in order to meet the country's needs. It could be accomplished either by bringing more area under wheat cultivation or by reducing post-harvest losses. However, availability of irrigation water is the major constraint in bringing additional 'area under cultivation. On the other hand, the minimization of produce losses is the vital step towards the augmentation of the net availability of food grains. According to a most conservative estimate, about 10% of the cereals harvested of developing countries are lost annually (Chaudhry, 1982). Harvesting of wheat crop in a short possible time after maturity is necessary in order to reduce shattering losses and delay in sowing the next crop. Further, the natural calamities like rain, hailstorm and windstorm during harvesting season result in enhancing these losses. Iqbal (1980) concluded that the grain losses increased as the harvesting was delayed after the ripening of the crop i.e., from 3 % in first week to 7 % in third week.

In view of the problems mentioned above, it is the need of the hour to mechanize wheat harvesting operation in order to recover better yield by completing the

operation timely. Chaudhry (1979) found that the grain losses in bullock threshing, mechanical threshing, tractor threshing and combine harvester amounted to 3.11, 2.68, 2.01 and 1.2% respectively. The maximum losses were at bullock threshing and minimum for combine harvester. Thus the combine harvester not only minimizes the post harvest losses but also helps in shortening the harvesting period. Proper adjustment of machine parameters like cylinder speed, cylinder concave clearance, feed rate etc. contribute significantly in reducing the grain losses. Misadjustment of any of these parameters may lead to abnormal grain losses.

In view of the above identified problems, this study was designed to investigate the effect at various combine parameters on the recovery of wheat under different crop conditions. The objective of this study was to determine the effect of cylinder concave clearance and feed rate on the threshing efficiency of wheat under various crop conditions.

MATERIALS AND METHODS

A series of experiments were conducted in order to investigate the effect of various combine and crop parameters on the losses and quality of threshed grains. Wheat crop Pak-81 was harvested by employing the Massey Ferguson combine harvester 87/6. The cylinder speed was kept constant at 750 revolutions per minute according to manufacturer's recommendations. Field experiments were conducted at three levels of grain moisture content (26%, 19%, and 13%), three levels of cylinder-concave clearance (20 mm, 25mm, and 30mm), and three levels of feed rates.

The feed rate was calculated by the following formula (Yasin, 1989).

$$FR = \frac{F \times W \times Y}{C} \quad (1)$$

Where;

F.R. = Feed rate t/h,

F = Forward speed, km/hr,

W = Cutting width, m,

Y = Weight of crop t/ha, and

C = Constant = 10.

The calculated feed rate was 2.82, 3.77 and 5.64 t/h at machine forward speed of 1.37, 1.83 and 2.74 km/hr. For each possible combination of 3 x 3 x 3 levels of moisture content, concave-clearance and feed rate, the data were collected for grain damage, cylinder and rack and shoe losses. The cylinder loss was measured accurately by catching the straw coming out of the rack over a measured area of 9 sq. m. After the lost grain was shaken out, the un-threshed kernels were manually rubbed to recover any grain left in heads. The cylinder losses were measured in percentage as follows (Srivastava et al 1995)

$$CL = \frac{W_h}{Y} \times 100 \quad (2)$$

Where;

CL = cylinder loss (%),

W_h = weight of grain left in heads, and

Y = total yield of sampled area.

Rack and shoe losses were clean and under threshed grain in the walker plus shoe effluent. These losses were recovered by shaking the straw collected behind the combine harvester over a measured area of 9 m² and expressed in percentage. Addition of cylinder, rack and shoe losses yielded threshing losses of the combine under test.

The percentage of damaged grain was measured by collecting 100 gram samples. The damaged grains from the collected samples were taken out manually and weighed employing an electric balance. The grain damage is calculated as explained below (Srivastava et al 1995).

$$GD = \frac{W_d}{W_s} \times 100 \quad (3)$$

Where;

GD = grain damage (%),

W_d = weight of damaged grain, and

W_s = weight of the sample

All the experimental runs on any one day were completed in a minimum possible time to alleviate the problem of changing crop conditions. For the analysis of data, multiple linear regression technique was used

to evolve appropriate relationship between machine and crop parameters and grain losses and grain damage.

RESULTS AND DISCUSSION:

The effect of moisture content, cylinder-concave clearance and feed rate on total machine losses and grain damage of Pak-81 wheat variety were investigated. Statistically analyzed results have been presented in Table-1. For the analysis of data statistical Package (M. STAT) was employed. A multiple linear regression technique was used to develop equations for the respective total threshing losses and grain damage. In order to estimate contribution of individual and combination of parameters towards total losses and kernel damage, forward stepwise linear regression analysis was used.

i) Effect of Concave Clearance and Feed Rate on Grain Losses and Grain Damage

Table-1 depicts that the total losses at 26 % moisture content and feed rate of 2.82 t/h were 1.15, 1.17 and 1.2 % at 20, 25 and 30 mm concave clearance respectively. The grains damage recorded were 2.13, 2.00 and 1.55% for the respective three levels of concave settings and the feed rate mentioned above. By increasing feed rate up-to 3.77 t/h the total losses jumped to 1.27, 1.45 and 1.61 %. At 5.64 t/h feed rate, the losses almost doubled to those recorded at 2.82 t/h feed rate.

The results of this study clearly indicate that the total losses increased with the increase of feed rate at all levels of concave clearance employed in this study. This may be attributed to the over-loading of the combine and the decrease in grain damage at the same time occurred could be due to cushioning effect of threshing material in the cylinder. The decrease in grain damage with an increase in feed rate has also been documented by Vas and Harrison (1969) and Caspers (1966) for conventional combines.

At 19 % moisture content the total grain losses were less than that at 26%. Nevertheless, the losses showed a decreasing trend for all the feed rates as the concave clearance was increased from 20 to 30 mm (Table-1). The decrease in the total grain losses with the decrease in moisture content occurred due to the improvement of thresh-ability conditions in the cylinder. This lessened the percentage of un-threshed kernels and hence the total grain losses. The improvement of threshability conditions in cylinder at 19% moisture has also been supported by Harlen (1981).

Table 1. Effect of moisture content, feed rate, and concave clearance on total crop loss and grain damages

Moisture Content (%)	Feed rate (t/h)	Grain losses (L) and grain damage (D) in % at different concave clearance (CC) in mm					
		CC ₁ = 20		CC ₂ = 25		CC ₃ = 30	
		L	D	L	D	L	D
26	2.82	1.15	2.13	1.17	2.00	1.2	1.55
	3.77	1.27	2.00	1.45	1.80	1.61	1.55
	5.64	2.13	1.78	2.16	1.52	2.21	1.40
19	2.82	1.13	2.36	1.01	2.16	0.94	1.93
	3.77	1.25	2.12	1.18	1.96	1.15	1.72
	5.64	2.07	1.98	1.98	1.85	1.75	1.60
13	2.82	1.31	3.09	1.19	2.89	0.98	2.25
	3.77	1.49	2.84	1.30	2.57	1.25	2.30
	5.64	2.69	2.58	2.29	2.36	1.89	1.87

The grain damage at 19% moisture content decreased with the increase in concave clearance for all feed rates. For example, at 2.82t/h feed rate the losses decreased from 2.36 to 1.93 % when the concave clearance was increased from 20 to 30 mm. The percentage of grain damage was relatively higher at 19% moisture content compared with 26%. This happened due to the reason that dried kernels have higher tendency to breakage particularly at the fixed cylinder speed.

At 13 % moisture content the total grain losses increased with the increase of feed rate at any fixed concave clearance. For example, when the feed rate was varied from 2.82 to 5.64 t/h, the total losses recorded varied from 1.31 to 2.69, 1.19 to 2.29 and 0.98 to 1.89 % at 20, 25 and 30 mm concave

the rack and shoe losses. However, the grain damage was reduced with the increase in feed rate and the concave clearance (Table-1). This may be attributed to the fact that high concave clearance and feed rate created a cushioning effect in the threshing cylinder resulting in less impact force on the individual kernels and hence less grain damage.

ii) Models of total losses and grain damage

In order to pin point the extent to which variables of machine and crop parameters affect the total grain losses and grain damage, a multiple linear regression technique was used. The following equations expressing total losses and grain damage in percent were evolved.

$$\begin{aligned} \text{Total loss} &= 2.166 - 0.0126 \text{ MC} - 0.0886 \text{ CC} - 0.000217 \text{ FR} \\ &+ 0.005 \text{ MC} \times \text{CC} + 0.023 \text{ MC} \times \text{FR} \\ &+ 0.0165 \text{ CC} \times \text{FR} - 0.001 \text{ MC} \times \text{CC} \times \text{FR} \end{aligned} \quad (4)$$

(R² = 0.91)

$$\begin{aligned} \text{Grain damage} &= 5.0015 - 0.00325 \text{ mc} - 0.0146 \text{ cc} + 0.1611 \text{ FR} \\ &- 0.0012 \text{ MC} \times \text{CC} - 0.013 \text{ MC} \times \text{FR} - 0.0167 \\ &\text{FR} \times \text{CC} + 0.0007 \text{ MC} \times \text{CC} \times \text{FR} \end{aligned} \quad (5)$$

(R² = 0.92)

Where, MC = Moisture content (%), CC = Concave clearance, mm, and FR = Feed rate, t/h

clearance respectively (Table-1). However, at any particular feed rate, the grain losses decreased with the increase of concave clearance. At 5.64 t/h feed rate, the losses decreased from 2.69 to 1.89% for a corresponding increase in concave clearance from 20 to 30 mm with a step increase of 5mm. Similar results were obtained for the other feed rates as shown in Table-1. High losses at higher feed rate were observed due to lower moisture content of crop causing over-threshing of wheat and hence resulting in increasing

The equation-4 revealed that the moisture content, concave clearance, and feed rate were important parameters which affected the total crop loss significantly. The equation-5 indicates that the moisture content and concave clearance were important crop and machine parameters for grain damage. The high values of R² indicate that the above developed models were appropriate to explain the relationship between these parameters and were fitting well their respective data sets.

Table 2. Forward stepwise multiple linear regression analysis for determination of impact of various parameters on total losses

Parameter	Ranking order	Max. R ²
FR	1	0.8364
FR x CC	2	0.863
MC x CC	3	0.8652
MC	4	0.8965
CC	5	0.9121
MC x Fr	6	0.9152
MC x FR x CC	7	0.9203

Table 3. Forward stepwise multiple linear regression analysis for determination of impact of various parameters on kernel damage

Parameter	Ranking order	Max. R ²
MC x CC	1	0.7398
FR	2	0.8819
MC x FR x CC	3	0.8898
FR x CC	4	0.8912
MC x FR	5	0.9203
CC	6	0.9215
MC	7	0.9230

The impact of various parameters on total losses and kernel damage was determined using forward multiple linear regression analysis technique. The results shown in table-2 & 3 feed rate were found the most important parameters for causing total grain losses and the interaction of moisture content and concave clearance caused maximum kernel damage.

It is depicted from Table-2 that Feed rate played a major role in affecting the total crop loss whereas the interaction M x MR x CC insignificantly contributed towards total crop loss. Table-3 revealed that MC x CC interaction played a major role in increasing grain damage whereas MC stood at ranking order of "7" for affecting the grain damage.

3. Minimum grain damage was observed at 26% moisture content and 30 mm concave clearance. The recorded grain damage was 1.4% at 5.64 t/h feed rate.
4. For over matured crops minimum grain losses may be obtained by adjusting the combine forward speed and concave clearance at 1.37 km/h and 30 mm respectively for feed rate of 2.82 to t/h.
5. Feed rate was found the important parameter influencing the total grain losses.
6. The interaction of moisture content and concave clearance played a pronounced role towards grain damage.

CONCLUSIONS

The following conclusions were drawn from the results obtained in this study:

1. As the feed rate increased, the total grain losses increased and the breakage of threshed grain decreased.
2. Minimum grain losses obtained at 19% moisture content was 0.94% at concave clearance of 30 mm.

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Influence of selected combine and crop parameters on kernel damage

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