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Synthesis a mechanical harvester to increase performance efficiency and reduce losses

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Abstract

Use of modern technologies in agricultural operations, especially in harvesting equipment for grain crops, has created a huge scientific breakthrough in reducing crop loss and increasing some properties. Experiment was conducted in one of the fields of Al-Shtrah 2022. This research studied Performance efficiency, total losses, loss threshing unit, and the amount of stalks scattered behind the harvester. The best Indicator involved three levels of harvester speeds (2.50, 3.50, 4.50 $km.\ h^{-1}$), and levels of clearance between cylinder and concave (12, 15, 20) mm. Factorial Experiments under (RCPD) with three replications was used in the study. It was verified the superiority harvester speed 4.50 $km.h^{-1}$ gets the highest performance efficiency 95% and less loss threshing unit 79%, while the speed 2.50 $km.hr^{-1}$ gets less total losses 1.83% and loss threshing unit 1.24 $kg.dunam^{-1}$, clearance cylinder and concave 12 mm gets the lowest percentage of total losses 2.41%, losses threshing unit 79%.

Keywords: Threshing unit, stalks, harvester speeds, grain crop

Introduction

Mechanical harvesting is the ideal solution for farmers to overcome problems while harvesting various types of crops, especially grain crops. Some may be forced to harvest crops at the beginning of the season and before they mature in order to market them at high prices, especially with crops that are available in the markets on a seasonal basis (Petere 2016) [1].

Recently, there have been many complaints from farmers as a result of the effort expended in harvesting operations and the long period to complete the manual harvesting work (Sheikh &Houshyar 2010) [10], which causes high costs and delays in marketing the crop, which reduces profits. (Benaseer *et al*., 2018) [11] The use of modern mechanization in all agricultural operations, including mechanical harvesting, has greatly helped in controlling the harvesting process, which reduced harvest time, which led to better exploitation of the land by the farmer in terms of planting and harvesting at the appropriate time (Albann 1998) [4]. Harvesting machines are considered among the most important mechanical field machines in terms of use, work average, and productivity, and they differ from one crop to another (Hamazah *et al*., 2020) [12]. The causes of crop loss are due to a number of cases, including mismanagement of the harvesting machine, failure to use the appropriate speed for work, the condition of the crop (Kumar *et al*., 2018) [14], or lack of maintenance and organization of the harvester units. In good harvest operations, especially with regard to wheat and barley, the total losses rates are less than 5%, but in Iraq the percentage is greater and may reach 15% (Bin Abdullah 2019) [6].

One of the most important factors that affect increasing the efficiency of the harvester, especially when harvesting a wheat crop, is the moisture percentage of the plant (Albann, 1998) [4]. When it increases, there is a lack of good separation of the grains from the stalks, and a large portion of them remains with the remains of the stalks behind the harvester. However, if the moisture percentage is low or the grains are dry, in this case it will occur. Grain scatters in front of the harvester as a result of collision with the harvester's cutting unit. The moisture percentage of the wheat crop is 14-16% (Singh *et al*., 2001) [7].

The use of control systems with the harvester ensures high-quality performance of various technological operations, including the direction of the harvester through machine vision and external signal sensors for process residues during harvesting, which will lead to an increase in the harvester's productivity by 2-3 times (Mohammed & Jassim, 2021) [8]. The use of modern technologies gives a clear picture of field maps and the traffic of harvesters and other agricultural machines for their various uses in the field through the use of a monitoring system for the harvester and dividing the field in order to determine the areas of loss and the factors affecting the amount of crop losses (Alsammaraie and Saba, 2021) [2]. According to (Al-Jubouri *et al*. 2012) [2], the speed of the harvester has a significant impact on the percentage of crop and grain loss, and its effect is on the cutting unit that is in direct contact with the crop through rotating or reciprocating moving parts. It was also indicated that the total loss from the threshing unit may reach 11% of Total gross product.

losses in threshing unit increases due to the incorrect calibration for the clearance between cylinder and concave, as the lack of clearance with increasing speed of the cylinder leads to the broken of the grains and an increase in straw with the grains (Albann, 1997) [3]. Performance efficiency is defined as the ratio of separated grains (weight in grain tank) to the total amount of grains (total weight). It is expressed as a percentage and may reach 85% or more. It increases by increasing the speed of combine harvester and reducing clearance between cylinder and concave (Isaac *et al*., 2006) [12].

Materials and Methods

Research was conducted on area of Shatrah, Iraq in season in 2022. Results were statistically analyzed and significant differences were tested using the least significant difference (LSD) method at the probability level (0.05) Factorial Experiments under complete randomized block design. With three replication in this experiment. distributed first factor harvesting speed at three levels 2.50, 3.50 and 4.50 km.hr^{-1} on the secondary plot, second factor clearance between cylinder and concave, at three levels (12, 15, and 20 mm) on main plot. The research included 3*3**3= 27 experimental units. The moisture content at harvest was 16%, harvesting was using a New Holland has a working width of 4.0 m, a diameter cylinder 0.56 m, a width threshing cylinder 1.3 m, an opening upper sieve 12 mm and a hole lower 4 mm. diameter air fan is 0.60 m and its speed is 500 rpm. Reel index 1.25. Studied attributes:

Performance Efficiency = (total grain in tank/Gross yield) *100. (Patel *et al*., 2013) [5].

Total losses = losses cutting unit + loss in threshing unit +losses in cleaning unit

Results

Performance efficiency %

Table 1. Shows effected the harvester speeds, and clearance between cylinder and concave, and interactions between them in performance efficiency Increasing harvester speeds from 2.54 to 3.50 and then to 4.50 km.hr^{-1} caused an increase in performance efficiency from 91% to 93% and then to 95%. Because increasing speeds harvesting will lead to harvesting crop in less time and increasing the amount of grains resulting from harvest in relation to time and speed of separating grains from stalks. This is consistent with the results reached (Al- Rajaboo, 2012) [2].

Impact clearance between cylinder and concave in performance efficiency, as it is noted that clearance between cylinder and concave 12 gets highest 95% (Table 1) while clearance 18 mm gets lowest value was 92%. Interaction between harvester speed 4.5 km.hr^{-1} and clearance cylinder and concave 12 mm gets highest value which amounted 97%.

Table 1: Effect of harvester speeds, clearance between cylinder and concave and the interactions between them in performance efficiency %

Average speeds		**Clearance cylinder and concave mm**			**Harvester speeds**
		18	**15**	**12**	**Km.hr^{-1}**
0.91		0.91	0.90	0.93	2.5
0.93		0.90	0.93	0.96	3.5
0.95		0. 94	0.96	0.97	4.5
N.S	LSD	N.S			LSD
		0.92	0.93	0.95	Average clearance
		N.S			LSD

Total losses %

Indicates to effected harvester speeds, and clearance between cylinder and concave, and the interactions between them in total losses. Increasing harvester speeds from 2.54 to 3.50 and 4.50 km.hr^{-1} caused an increase in total losses from 1.83 to 2.80 and 4.23 (Table 2). Because increasing speeds will lead to flow crop to cutting unit and threshing unit lead to losses stalks without separation grain This is consistent with the results reached (Galib, 2024) [15].

According Table (2) impact clearance between cylinder and concave in total losses, as it is noted that increasing clearance from 12 to 15 and then to 20 mm lead to increase total losses from 2.41% to 3.20% and 3.25%. Interaction between harvester speed 4.5 km.hr^{-1} and clearance cylinder and concave 18 mm gets heights total losses which amounted 4.47%. This is consistent with the results reached.

Table 2: Effect of harvester speeds, clearance between cylinder and concave and interactions between them in total losses %

Average speeds		**Clearance between cylinder and concave mm**			**Harvester speeds**
		18	**15**	**12**	**Km.hr^{-1}**
1.83		2.20	2.07	1.23	2.5
2.80		3.10	2.97	2.33	3.5
4.23		4.47	4.57	3.67	4.5
0.69	LSD	N.S			LSD
		3.25	3.20	2.41	Average clearance
		0.69			LSD

Losses threshing unit %

It was verified the superiority speed harvester 4.50 km.hr- gets less losses threshing unit which amounted 0.79%. while the highest losses 1.48% in first speed 2.5 km.hr^{-1} (Table 3) Because increasing speeds harvesting will lead to harvesting crop in less time and increasing the amount of grains resulting from harvest in relation to time and speed of separating grains from stalks. This is consistent with the results reached (Sheikhand & Houshyar, 2010) [10].

Impact clearance between cylinder and concave in losses threshing unit (Table 3), as it is noted that the using clearance from 12 mm lead to gets decrease losses from 0.75%. The interaction between harvester speed 4.5 km.hr^{-1} and clearance cylinder and concave 12 mm gets less losses which amounted 0.53%.

Table 3: Effect of harvester speeds, Clearnce between cylinder and concave and the interactions between them in losses threshing unit %

Average speeds		Clearance between cylinder and concave mm			Harvester speed
		18	15	12	Km.hr^{-1}
1.48		1.70	1.83	0.93	2.5
1.00		1.07	1.13	0.80	3.5
0.79		1.17	0.67	0.53	4.5
0.38	LSD	N.S			LSD
		1.31	1.21	0.75	Average clearance
		0.38			LSD

Stalks scattered behind the harvester: kg. Dunam^{-1}

Less scattering of stalks behind harvester is a good characteristic of mechanical harvesting (Table 4). Superiority harvester speed 4.50 km.hr^{-1} on gets less stalks scattered behind harvester amounted 1.76 kg. Dunam^{-1} while clearance between cylinder and concave 12 mm gets 1.20 kg.dunam^{-1}. This is consistent with the results (Patel *et al*., 2013) [5]. Interaction between harvester speed 2.5 km.hr^{-1} and clearance cylinder and concave 12 mm gets lowest value which amounted 1.08 kg. Dunam^{-1} (Table 4) while interaction between harvesters speed 4.5 km.hr^{-1} and clearance 18 mm gets heights value which amounted 2.30 kg. Dunam^{-1}

Table 4: Effect of harvester speeds, clearance between cylinder and concave and interactions between them in stalks scattered behind the harvester kg. Dunam^{-1}

Average speeds		Clearance between cylinder and concave (mm)			Harvester speeds
		18	15	12	Km.hr^{-1}
1.24		1.47	1.17	1.08	2.5
1.49		1.70	1.60	1.17	3.5
1.76		2.30	1.63	1.37	4.5
0.46	LSD	N.S			LSD
		1.82	1.46	1.20	Average clearance
		N.S			LSD

Conclusions

From the above results, speeds harvester 2.5, 4.5 km.hr^{-1} gets highest performance efficiency, less total losses, lowest loss threshing unit and stalks scattered behind harvester. While the clearance between cylinder and concave 12 mm superior in all studied properties, monitoring system gets the power in management harvesting by monitoring the operation of all harvester units and directly repairing faults that occur during work. Therefore, we recommend using a with harvester speed 2.54 km.hr^{-1} and clearance 12 mm

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