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Evaluation the performance of the locally Developed Corn Thresher Machine from Manual to Mechanical System

Ayoub Abdel Aziz Mohammed Al-Dola [1] **Adel Ahmed Abdullah Rajab[2]**

ayoob.21agp29@student.uomosul.edu.iq dr.adil.aa@umosul.edu.iq

[1] Nineveh Agriculture Directorate, Iraq.

[2] Agricultural Machines and Equipment, Collage of Agriculture and Forestry, University of Mosul, Iraq

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Abstract

This study was conducted to develop corn thresher located in the College of Agriculture and Forestry, University of Mosul - Iraq in 2022, and this thresher operated by manual system. 1The factors were studied using two varieties of corn (Rayal, ZP), rotation speed 50, 100 rpm, and clearance between threshing wheel and pressing plate 10, 20 mm on some indicators, namely: productivity ($kg.h^{-1}$), percentage of damaged grains (%), percentage of non-threshed grains (%).Operating costs (dinars. kg^{-1}), the experiment was implemented according to a Complete Randomized Design (CRD), and with three replications .The main objectives of the study were to develop a manual system of thresher machine and to select the most appropriate operating factors that affect its performance. The results of the study showed that the (Rayal) variety was superior to the (ZP) variety in recording the lowest percentage of damaged grains. The rotation speed 100 rpm achieved the highest productivity values and the lowest values for each of (percentage of non-threshed grains, Operating costs), The clearance 20 mm was superior in achieving the highest values for productivity and the lowest values for the percentage of damaged grains, while the clearance 10 mm achieved the lowest values for the percentage of non-threshed grains.

Key words: *thresher development, thresher speed, corn varieties, productivity, damaged grains, non-threshed grains.*

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Correspondence Author: Ayoub Abdel Aziz Mohammed Al-Dola -ayoob.21agp29@student.uomosul.edu.iq

Introduction

Yellow corn is considered one of the most important main grain crops, as it ranks third globally after wheat and rice crops in terms of cultivated area and production [1], because of its great importance in human nutrition and animal fodder, and yellow corn considered to be a fodder crop that presides over the universal fodder list because it's preferable in comparison with the other grains due to its highest productivity [2] in addition to its uses in many industrial fields. and its grains are extracted from the finest types of oils with high nutritional value because they are free of cholesterol [3]. Its grains, whole or crushed, are used in the preparation of concentrated diets for livestock and poultry, especially in fattening diets because they contain a high percentage of Starchy materials and proteins. Storage and enhancing the ease of handling grain, and the difficulty of the process of forfeiting depends on the cultivars grown and the humidity as well as the degree of maturity of the grain [4] and Thresher can be performed Manually, which is a very slow process that requires a lot of effort and labor and takes a long time, in addition to its low productivity [5], or it is done automatically using electric motors or through the power take-off shaft in agricultural pullers, and these machines contribute to separating the grain from the grain over a period of time. short to be stored in a timely manner before the rainy season [6]. [7] mentioned that an increase in the rotational speed of the skewing drum led to an increase in productivity and consumed capacity, as noted [8] that the percentage For damaged grains, it increased with the increase of the rotational speed of the forging cylinder and decreased with the increase in the clearance between the cylinder and the concave. [9] confirmed that the motor-driven forgings are the most feasible to operate compared to other foraging systems. Based on the foregoing, the problems of manual skipping prompted the need to improve the technology used in skipping operations to ensure high quality and less effort compared to the manual system. The grains are damaged as a result of beating and friction, which negatively affects the quality of the excessive grains. This was the aim of the study by selecting the most appropriate operating factors that affect its performance.

Materials and methods

This study was conducted in 2022 in Al-Hamdani factory to develop the thresher machine maize from the manual system to the automated system Figure (1) by designing and manufacturing the structure, feeding hopper and outlets for grains and cobs as well as manufacturing rollers in addition to equipping it with an electric motor with a capacity of 1 horsepower and a maximum speed of 1100 rpm. its speed by inverter.

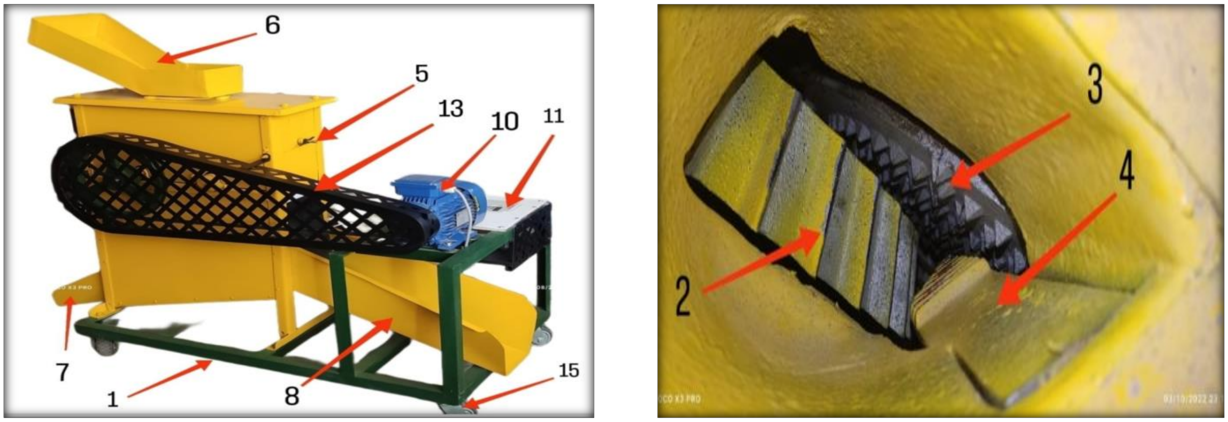

Figure (1) shows the development of thresher- machine from the manual system to the automated system

1- The frame 2- threshing wheel 3- picker Grain disc 4- pressing plate 5- Clearance regulation nut 6- Feeding hopper 7- Grain outlet 8- Corn cob outlet 10- Electric motor 1 HP 11- Inverter 12- Belt and pulleys 13- A protective cover for the belt and pulleys 15- wheels

The thresher unit consists of a scattering wheel in the form of a conical gear with a diameter of 365 mm made of cast iron and installed on an axle that rotates on two bearings installed on the structure Figure (2) where there is a disc on the opposite side of the wheel, for the purpose of picking grain which is a disc made of Cast iron has a diameter of 370 mm and its surface contains a group of conical protrusions distributed in seven regular rings with diameters 95, 115, 145, 180 , 230 , 280 , 320 mm has a base with a diameter of 10 mm, and a length of 10 mm, as shown in Figure (3) that works to pick up grains from the cob by friction and its rotational movement.

Figure (2) shows the separation wheel

And the opposite side of the disc there is a (spring iron piece pressing lever loaded) From the back side, by a rod that ends with a screw and a nut, through which the required distance can be controlled according to the diameters of the corncobs and the lower part of it contains grooves that act to force tightness on the Corncobs during the separation process Figure (4)

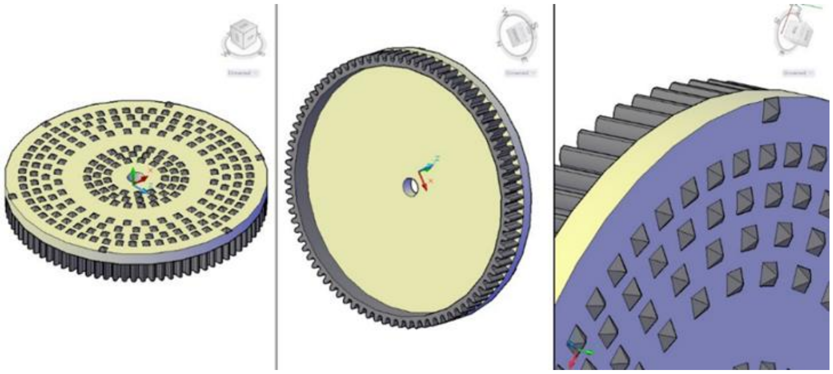

Figure (3) shows the grain picking disc

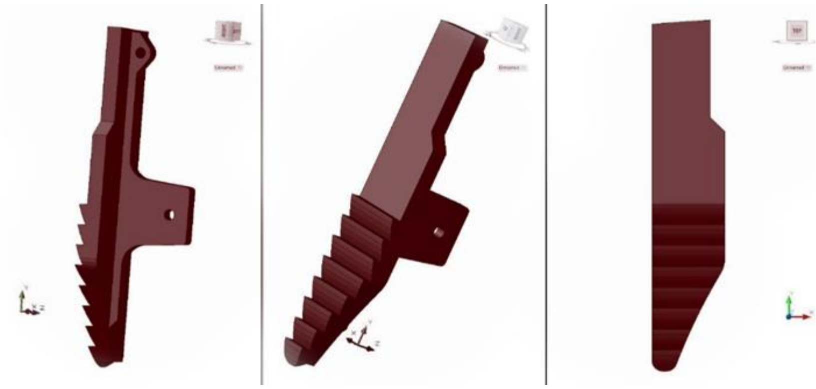

Figure (4) shows the pressing plate

By virtue of the design of the separation unit, we can be noted that the picking up to down wheel the picking disc and the lever form a triangular hole to pass the cobs through it The size of this slot must be appropriate to the size of the corn cob by tightening or loosening the lever nut [10] as shown in Figure (5).

Figure (5) shows the triangular distance between the parts of the thresher unit

Then, the experiment was carried out according to a Complete Random Design (CRD), and the study tested to the following factors: two varieties of corn (American Rayal, Yugoslav ZP) with rotation speed and clearance at two levels 50, 100 rpm and 10, 20 mm, respectively, so that the number of treatments in the experiment was eight 2 * 2 * 2 and refiners with three replications where the number of experimental units reached 24 experimental units Tested by Duncan's multiple range test to compare the average under a Probability level 0.05 and 0.01 [11] . The moisture content of the grains was measured by a moisture content meter and it was 13.1 and 12.2 for Rayal and ZP corn cultivars, respectively, Samples were taken randomly from both variety with three corncobs for each sample. The samples were weighted by an electric balance before the thresher process The corncobs were passed to the separation unit through the feeding hole with one corncob. for each reading. Measured tension difference is done that is consumed by electric motor, and the set the time required perform the thresher to process was calculated for each experimental unit. This process was repeated three times for each replications then the thresher grains were collected through the grain exit pathway, as well as the collection of their cobs through the cobs exit pathway. At the end of the process, the grains were collected for each experimental unit and placed in numbered bags and weighted in order to calculate the indicators for each variety Table (1) shows the physical characteristics of the varieties used in the experiment.

Table (1) shows the most important physical characteristics of the varieties

variety	Specific weight ($kg.hcl^{-1}$)	Moisture content (%)	Weight 1000 Grains (gm)	length of the grain (mm)	width of the grain (mm)	thickness of the grain (mm)	Cob length (mm)	Cob diameter (mm)	number of grain lines
ZP	68.3	12.2	213	12	8.1	4.8	220	43.5	16
Rayal	71	13.1	206	13	6	5	190	49	20

An evaluation of the performance of thresher - grain was carried out by studying the following indicators for each variety

1-Productivity: Productivity was calculated by weighting a sample resulting from the thresher process for each replications by using a sensitive electronic scale and a stopwatch to calculate the time of thresher, and then dividing the resulting weight by time from the following law [12] :

Productivity = (product weight * 3600) / (time * 1000) ($kg.h^{-1}$) ………….(1)

2- percentage of damaged grains (%): The damaged and broken grains were separated from the resulting sample by hand and then weighed with a sensitive scale. The visible grain damage was estimated as a percentage of the total weight of the sample from the following law [13] :

Percentage of damaged grains (%) = (damaged grains weight) / (total sample weight) *100 …………………….(2)

3-Percentage of non-threshed grains (%): After the thresher process, non-threshed grains were removed from the cobs then manually, weighted with a sensitive scale, and then estimated as a percentage of the total weight of the sample according to the following law [14] :

Percentage of non-threshed grains (%) = (non-threshed grains weight) / (total sample weight) *100 …………………............ (3)

4-Operating costs: Operational cost was calculated on the basis of productivity through the following equation [15] :

C = P/h+ (1/e + i/2 + t + r) + (W * f) + S /144 ……………(4)

Where: **C**: Hourly cost in ID.h^{-1}, **P**: Capital investment in ID., **h**: Yearly operating hours, e: Life expectancy in years, **i**: Interest rate, **t**: Taxes and overhead ratio, **r**: Repairs ratio to the total investment, **W**: Power of motor in kW, **f**: Power unit price in ID., **S**: Labor salary rate per month in ID. and **144**: Reasonable estimation of monthly working hours. The **total cost** of the forfeiture process was estimated using the following equation [16] :

Operating cost (diners.kg^{-1}) = C / Actual productivity (kg.h^{-1}) ………………(5)

Results and discussion

1- Productivity (kg.h^{-1}):

It is noted from Table (2) that the effects of the variety factor was non- significantly affected by the productivity characteristic, while the rotation speed was significantly effected by the productivity indication, as the rotational speed recorded 50 rpm the lowest value of productivity, which reported 130.873 kg.h^{-1}, while the rotational speed recorded 100 rpm the highest value of productivity, which amounted to 231.874 kg.h^{-1}, and the reason for this is that by increasing the speed leads to the increase in the amount of separated seeds which are getting out after the threshing, synchronized with the increase of each speed, and this agrees with the results of [2] As it is clear from Table (1) that the effects of distance was significant on productivity indication as the clearance of 10 mm recorded the lowest value of 166.397 kg.h^{-1}, while the clearance of 20 increase in giving it the highest value of 196.350 kg.h^{-1} The reason for this is due to the appropriate pressure applied by the compressor lever on the corncob which reduces its friction and ease of passage during the thresher process and thus an increase in productivity and This is consistent with what was confirmed by [7] As for the interaction. between (variety & rotational speed) And (variety and volume of distance) the table showed that there were no significant differences in the characteristic of productivity. It is noted from the table that there are significant differences at the interaction between rotational speed and distance where the lowest value of productivity was recorded, which amounted to 121.79 kg.h^{-1} at a rotational speed of 50 rpm and a clearance 20 mm, while the speed of rotation was recorded 100 rpm with a clearance of 20 mm, the highest value of productivity, which reached 270.91 kg.h^{-1} for the same reasons mentioned above. As for the triple interaction, there were no significant differences.

Table (2) Effect of the studied factors and their interaction on the productivity (kg.h^{-1})

variety	Rotational speed (rpm)	Clearance (mm)		Interference between variety and rotational speed	variety	Rotational speed (rpm)
		10	20			
Rayal	50	137.75	109.94	123.85		
	100	195.12	266.26	230.69		
ZP	50	142.15	133.65	137.90		
	100	190.56	275.55	233.06		
Interference between variety and clearance	Rayal	166.44	188.10		177.27	
	ZP	166.36	204.60		185.48	
Interference between rotational speed and clearance	50	139.95 C	121.79 C			130.87 B
	100	192.84 B	270.91 A			231.87 A
Clearance (mm)		166.39 B	196.35 A			

The highest value is the better.

2- percentage of damaged grains (%):

Table (3) shows that the (Rayal) variety was significantly superior in recording the lowest value for the percentage of damaged grains, which amounted to 0.120%, while the (ZP) variety recorded the highest value in the percentage of damaged grains, which amounted to 0.451%, and the reason for this is attributed to the size and weight of Cobweb, which have a clear effect on this trait, as it was observed that the percentage of affected grains increased with the increase in cob weight, in addition to the genetic factor and the severity of the grains' association with pollen and this is consistent with what was found by [17]. It is noted from the table that the effect of the clearance factor was also significant in terms of the percentage of damaged grains, as the clearance size of 10 mm recorded the highest value in the percentage of damaged grains, which amounted to 0.433%, while the size of clearance 20 mm recorded the lowest percentage in the characteristic of damaged grains, which amounted to 0.138%. The reason for this is the lack of pressure applied by the tongue pressing on the cob and the rotation of the cob regularly during the cob process, which leads to a lack of friction with the components of the cob unit, sufficient to remove grains from the alkali and with minimal damage to me, and this is consistent with what was mentioned by [8] and [12]. As for the spinning speed factor, there were no significant differences between the spinning speeds 50 and 100 cycles.min-1 in the characteristic of the percentage of damaged grains. (Rayal) with a rotation speed of 50 rpm recorded the lowest value in the characteristic of the percentage of damaged grains, which amounted to 0.102%, while the cultivar (ZP) with a rotation speed of 100 rpm recorded the highest value in the characteristic of the percentage of damaged grains, which It amounted to 0.485%. The reason for this is due to the size and shape of the excessive grains, as well as to reducing the effect of blows on the grains at low speed during the scattering process, and thus a decrease in the percentage of damaged grains, and this is consistent with what was mentioned, by [18]. The factor of cultivar, size, and clearance was also significant in the percentage of damaged grains, as the variety (Rayal) with a clearance of 20 mm excelled in recording the lowest value in the percentage of damaged grains, which amounted to 0.108%, while the cultivar (ZP) with a clearance of 10 mm recorded the highest value for the percentage of grains. Affected, which amounted to 0.733%, the reason for this was attributed K to the lack of effort exerted by the tongue pressing on the cob during the process of loosening, which reduces the friction between the grains when increasing the clearance, and this is consistent with what was shown by [19], but when there was an overlap between the rotational speed and the clearance, it was noticed that there was no Significant differences in the proportion of damaged grains. It was also noted from the table that there were no significant differences during the tripartite interaction between the studied factors in terms of the percentage of damaged grains.

Table (3) The effect of the studied factors and their interaction on the percentage of damaged grains %

variety	Rotational speed (rpm)	Clearance (mm)		Interference between variety and rotational speed	variety	Rotational speed (rpm)
		10	20			
Rayal	50	0.111	0.093	0.102 C		
	100	0.155	0.123	0.139 C		
ZP	50	0.662	0.166	0.417 B		
	100	0.805	0.171	0.485 A		
Interference between variety and clearance	Rayal	B133 0.	0.108 B		0.120 B	
	ZP	0.733 A	0.168 B		0.451 A	
Interference between rotational speed and clearance	50	0.408	0.129			0.278
	100	0.458	0.147			0.295
Clearance (mm)		0.433 A	0.138 B			

The lower value is the better

3- Percentage of non-threshed grains (%):

Table (4) shows that the effects of variety was not significant in the quality of proportion of non- tenacious grains, while The size of the distance was significantly superior to the proportion of non- distributed grains, as the clearance 10 mm recorded the lowest value for the proportion of non-tenacious grains, which was 0.261 % , while the clearance 20 mm recorded the highest value for the proportion of grains. The tenacious grains, which reported 0.974 %, and the reason for this is due to the lack of pressure placed on the corn cob, by the pressing lever, which leads to its displacement and the lack of rotation of some of the corn cob completely while passing through the thresher unit. This is consistent with what was mentioned by [7] and [20] It is also noted in the table that the rotational speed is significantly superior to the percentage of tenacious. grains, as the rotation speed was recorded as 100 rpm the lowest value for the percentage of tenacious grains, which reported 0.417 %, while the speed of 50 rpm was recorded The highest Value of the percentage of tenacious grains was 0.817%, and the reason for this is that increasing the rotation speed leads to an increase in friction and pressure on the grains, and that thresher occurs at any point that corresponds to the diameter of the corncob and thus ease of thresher. This is consistent with the findings [21]. As for the interaction action the table showed that the effect of the interaction between the class and the rotation speed was significant, as the variety (ZP) increase with the speed 100 rpm by recording the lowest value of the tenacious, which reported 0.209 %, while it gave (ZP) with the speed 50 rpm The highest value of the tenacious grain, which amounted to 0.925 %, and the reason for this is due to the speed of rotation as mentioned previously. While it is noted from the table that the effect of the interaction between class and volume of distance as well as the eve interaction between (rotation speed and volume of clearance in the quality of the percentage of non- distributed grains was not significant. While it is noted from the table that there are significant differences at the triple interaction, where the lowest value of the percentage of tenacious dis grain was 0.140 % at the interaction of the variety (ZP) and the rotational speed 100 rpm with a yield 10 mm, while the highest value recorded For the same quality at the interaction of the variety (ZP) with a speed of 50 rpm with a clearance 20 mm, which was 1.538 %, and the reason for this is due to the effect of the threshing process by the pressure pointed to the corn by the presser lever and the centrifugal force and movement rotation caused by the picking up and down wheel during the thresher process will work to remove the grains from the cobs and with less mechanical damage..

Table (4) The effect of the studied factors and their interaction on the percentage of non-threshed grains %

variety	Rotational speed (rpm)	Clearance (mm)		Interference between variety and rotational speed	variety	Rotational speed (rpm)
		10	20			
Rayal	50	0.386 BC	1.034 AB	0.710 A		
	100	0.206 C	1.046 AB	0.626 A B		
ZP	50	0.312 C	1.538 A	0.925 A		
	100	0.140 C	0.278 C	0.209 B		
Interference between variety and clearance	Rayal	0.296	1.04		0.668	
	ZP	0.226	0.908		0.567	
Interference between rotational speed and clearance	50	0.349	1.286			0.817 A
	100	0.173	0.662			0.417 B
Clearance (mm)		0.261 B	0.974 A			

The lower value is the better

4-Operating costs (dinars.Kg^{-1}):

Table (5) shows that the effect of the factor of varieties and clearance was not significant in the characteristic of operating costs, while the table indicates that there are significant differences for the speed factor in the characteristic of operating costs, as the rotational speed of 50 rpm recorded the highest value for operating costs, which amounted to 33.308 dinars.kg^{-1}, while the rotational speed of 100 rpm recorded the lowest value, which amounted to 22.690 dinars.kg^{-1}. The reason for this is attributed to the fact that the operating cost is inversely proportional to the time required to thresh the grain when increasing the speed of the cylinder, and this is consistent with what was mentioned by [22], as for the interactions between (varieties and rotational speed) and (varieties and clearance size), the results showed that there were no significant differences in the nature of operating costs. While the overlap between rotational speed and clearance was significant, as the rotational speed recorded 50 rpm with a clearance of 20 mm, the highest value for the costs amounted to 35.736 dinars.kg^{-1}, while the lowest value for the costs was 15.928 dinars.kg^{-1} at the rotational speed of 100 rpm with a clearance of 20 mm and for the same reason previously mentioned, and it is noted from the table that there are no significant differences at the triple overlap between the studied factors.

Table (5)The effect of the studied factors and their interaction on the Operating costs (dinars.Kg^{-1})

variety	Rotational speed (rpm)	Clearance (mm)		Interference between variety and rotational speed	variety	Rotational speed (rpm)
		10	20			
Rayal	50	31.271	39.252	35.262		
	100	36.134	16.252	26.193		
ZP	50	30.486	32.221	31.354		
	100	22.769	15.604	19.187		
Interference between variety and clearance	Rayal	33.703	27.752		30.727	
	ZP	26.628	23.912		25.270	
Interference between rotational speed and clearance	50	30.879 A	35.736 A			33.308 A
	100	29.452 A	15.928 B			22.690 B
Clearance (mm)		30.165	25.832			

The lower value is the better

Conclusions

We conclude from the results obtained that the variety (Rayal) achieved the lowest values of the percentage of damaged grains, the rotation speed 100 rpm gave the highest values for productivity and the lowest values for each of (the percentage of non-threshed grains, operating costs), the clearance 20 mm achieved the highest value for productivity and the lowest value for the percentage of damaged grains, while the clearance 10 mm achieved the lowest values for the percentage of non- threshed grain.

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تقييم أداء مفرطة الذرة الصفراء المطورة محلياً من النظام اليدوي إلى النظام الآلي

أيّوب عبد العزيز محمد الدولة [1] **عادل احمد عبدالله رجب[2]**

ayoob.21agp29@student.uomosul.edu.iq dr.adil.aa@umosul.edu.iq

[1] مديرية زراعة نينوى، نينوى، العراق.
[2] قسم المكائن والالات الزراعية، كلية الزراعة والغابات، جامعة الموصل، نينوى، العراق.

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- البحث مستل من رسالة ماجستير للباحث الاول.

المستخلص

أجريت هذه الدراسة لتطوير مفرطة الذرة الموجودة في كلية الزراعة والغابات، جامعة الموصل– العراق في عام 2022 وكانت هذه المفرطة تعمل بالنظام اليدوي، تحددت الأهداف الرئيسية للبحث بتطوير آلة التفريط بالنظام اليدوي واختيار انسب عوامل التشغيل التي تؤثر على أدائها، تم تطوير هذه الآلة في معمل الحمداني في المنطقة الصناعية بمدينة الموصل وتم إجراء التجارب العملية لتقييم أدائها، كذلك وكانت عوامل دراسة صنفين من الذرة (Rayal , ZP) وسرعة الدوران 50 ، 100 دورة.دقيقة$^{-1}$ والخلوص بين عجلة التفريط واللسان الضاغط (10 ، 20) ملم على بعض المؤشرات وهي : الإنتاجية (كغم.ساعة$^{-1}$) ونسبة الحبوب المتضررة (%) ونسبة الحبوب غير المفرطة (%) وتكاليف التشغيل (دينار.كغم$^{-1}$)، تم تنفيد التجربة باستخدام التصميم العشوائي الكامل (CRD) وبثلاث مكررات. أوضحت النتائج تفوق صنف (Rayal) على صنف (ZP) في تسجيله أقل نسبة للحبوب المتضررة، حققت سرعة الدوران 100 دورة.دقيقة$^{-1}$ أعلى قيم للإنتاجية وأقل قيم لكل من (نسبة الحبوب غير المفرطة ، تكاليف التشغيل)، كما تفوق الخلوص 20 ملم في تحقيقه أعلى قيم للإنتاجية وأقل قيم لنسبة الحبوب المتضررة، بينما حقق الخلوص 10 ملم أقل قيم لنسبة الحبوب غير المفرطة.

الكلمات المفتاحية: تطوير المفرطة، سرعة المفرطة ،أصناف الذرة، الانتاجية، الحبوب المتضررة ، الحبوب غير المفرطة.