Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 02, NO. 01, 2017
http://www.nilevalley.edu.sd

Research paper

Development of Feeding Conveyor in Grain Stationery Thresher

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ABSTRACT

This study was conducted at the Faculty of Agriculture, Nile Valley University. It aims to develop the conventional grain thresher by the addition of a conveyor feeding belt to increase productivity and reduce operational costs. The improved thresher with conveyor feeding belt was compared with the conventional feeding. Both systems were evaluated in terms of labors requirement, costing and crops losses. For feeding, measurements were taken in all plots using three replications. Independent T- test with three replications was used for analysis of results. Results indicated that there is a significant difference between the threshing methods, for the required man-hrs./fed, labor-saving SDG/fed and crops losses between the two systems. The labour requirement was 2 man-hr./fed for the developed system compared to 6 man-hr./fed for the conventional one. The cost of labour for feeding was 32 SDG /fed compared to 75 SDG /fed with conventional system constituting 43 % of the harvesting operation cost. The total crop losses for traditional feeding was about 10% at feeding rate of 10 kg/min compared with 6% when using developed thresher with conveyor feeding at 10 kg/min feeding rate. The developed thresher with conveyor feeding is durable, easy to operate and with lower maintenance costs. All components of the machine were fabricated from local materials and total cost for the designed and developed conveyor feeding belt was only 1150 DSG.

Keywords: *Crops losses, designing, feeding conveyor*

تصميم وتطوير سير تغذية لدراسة المحاصيل الثابتة

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أجريت هذه الدراسة في كلية الزراعة- جامعة وادي النيل. تهدف هذه الدراسة لتطوير آلة درس الحبوب الثابتة بإضافة سير تغذية لزيادة الانتاجية وتقليل تكاليف التشغيل. تم اجراء مقارنة بين اداء الدراسة باستخدام سير التغذية وبطريقة التغذية التقليدية، من حيث احتياج العمالة، التكاليف والفاقد في المحصول. أظهرت النتائج تأثيراً عالياً ($P > 0.01$) لعملية التغذية بين آلة دراسة الحبوب المطوره (بالسير الناقل) ودراسة الحبوب التقليدية (يدوية التغذية) في احتياج العمال وتكلفتهم وزمن العملية وفاقد المحصول لعملية التغذية. ووجد اقل عدد للعمال (2 عامل) فقط بالنسبة لآلة الدرس المطورة بينما (6 عمال) في حالة آلة درس الحبوب التقليدية، وكانت اقل تكلفة لعملية تغذية الفدان/عامل للدرس المطورة (32 جنية سوداني) للفدان بينما تكلفة تغذية آلة الدرس التقليدية (75 جنية سوداني)، وكانت نسبة تكلفة العمال اقل بنحو 43 %. وجملة فاقد الحصاد لعملية التغذية لآلة الدرس التقليدية (يدوية التغذية) 10 % بمعدل تغذية 10كجم/دقيقة مقارنة بـ 6 % عند استخدام آلة الدرس المطورة (السير الناقل) لنفس معدل التغذية. معظم مكونات التعديل في آلة درس الحبوب من المواد المحلية بتكلفة حوالي 1150 جنية سوداني.

Introduction

Different models of stationary grain threshers have been imported to Sudan (G.A.S., 1996). They are simple in design, easily maintained, consume little power (35 - 40 hp) and have been designed with simple threshing, cleaning and bagging units.

However, there are claims of injuries associated with the stationary thresher. Rawal (1988) reported that the human factors associated with thresher injuries were 73 %. These included inattentiveness, wearing of loose garments, overwork and physical incapability. Mufti *et al*. (1989) reported that belt entanglement, electric shock and feeding crop without safety were main reasons attributed to thresher injuries, they also added that the mechanical failures responsible for injuries were 17%. Kumar *et al*. (2000) stated that threshing machine recorded 2 % of total agricultural injuries though they are used only for a few days in the whole year. Morad (1997) investigated threshing machine performance and concluded that threshing losses as well as threshing cost can be minimized when the feed rate of 1 ton/h, drum speed of 25 m/s, and moisture content of 20 % are considered for the used machine.

The main objectives of this study was to design and to test the performance of feeding conveyor belt for grain stationary thresher, and to compare Labouring requirement and cost of the conventional and developed systems.

Materials and Methods

Materials

The developed parts of the grain stationery thresher

This study conducted at the faculty of agriculture, Nile Valley University in Darmali, North of Atbara. Thresher developed by El-mowla *et al.* (2014) was employed in the stationary thresher Elshams with its technical specification shown in Table (1). All experiments were conducted using a stationery thresher before and after development. The elevation and plan of stationery thresher machine before and after development are shown in Figs. (1) and (2), respectively. Experiments were conducted using two crops: wheat and faba beans.

Methods

The developed feeding conveyor

A feeding device in the developed threshing machine was designed and assembled to increase machine efficiency and to reduce traumatic injuries during threshing process. The developed feeding device in the thresher machine consists of four main parts as shown in plates (1) and (2).

The frame

The frame consisted of inclined rectangular table of 245 × 197.5 cm. It was designed with these dimensions to help in handling the crops from the heap at an inclined surface of 35º to the feeding platform, which is at a height of 1.77 cm above the ground surface. This angle of elevation was determined through a micro-test by putting some faba bean and wheat crops on flat and smooth metal sheet, which was raised slowly from the horizontal position. The faba bean and wheat started to slide at an angle 37º. Therefore, a smaller angle 35º was chosen for calculation of the total length of the conveyor belt table by dividing the vertical height of the feeding platform 1.77 cm by sine 35º. Then an extra 39.88 cm were added to extend the length towards the threshing unit for a total length of 236 cm. The width of the thresher feeding plate frame was 120 cm. Therefore, the width of conveyor belt table was taken as 118 cm with 1 cm clearance at each side in order to have as great as possible conveyor belt area (Fig. 3).

Transmission system

The motion is transmitted from the threshing shaft connected to tractor P.T.O shaft, which provided with a fixed pulley of 20 cm diameter to transmit the motion through belt and pulleys to belt feeding shaft, which operate the belt for feeding the crop materials.

The belt drive and pulley

The distances between the centers of the driving shaft (threshing shaft 400 rpm) and the driven shaft (roller shaft 320 rpm) were 72.5 cm. The driven pulley was attached to the roller shaft. The driven pulley diameter was calculated by the equation applied by Hunt (1983):

$$\frac{\mathrm{PD_r}}{\mathrm{PD_n}} = \frac{\mathrm{rpm_n}}{\mathrm{rpm_r}} \ldots\ldots\ldots\ldots\ldots (1)$$

Where:

PD = pitch diameter, cm

RPM = shaft speed revolution per minute

r = drive sheave

n = driven sheave

$$\mathrm{PD_n} = \left(400 \times \frac{20}{320}\right) = 25\ cm$$

The belt length was calculated using the equation applied by Shigley and Mitchell (1983) and Helmy (1988):

$$\mathrm{L} = 2\mathrm{C} + 1.57(\mathrm{D} + \mathrm{d}) + \frac{\mathrm{D} - \mathrm{d}}{4\mathrm{C}} \ldots\ldots\ldots\ldots\ldots (2)$$

Where:

L = effective length of the belt.

C = distance between centers of pulleys.

D = effective outside diameter of the large pulley (sheave).

d = effective outside diameter of the small pulley (sheave).

$$\mathrm{L} = 2 \times 72.5 + 1.57(10 + 12.5) + \frac{12.5 - 10}{4 \times 72.5} = 187.5\ cm$$

The nearest standard size of V-belts from Table (3); B187.5 V-belt was used for power transmission to the roller shaft when using the pulleys of 25 cm diameter.

The rollers, shafts and bearings

Two rollers 97.5 long and 10 cm diameter were installed to support the conveyor belt. The rollers were made of galvanized steel tubes welded to a steel shaft 2.5 cm diameter and 115 cm long. Each roller was supported by two pillow-block ball bearings. The front drive roller shaft was 115 × 9.7 cm, which was extended 8 cm to one side and 12.59 cm to the other side (the driven pulley side).

Selected conveyor belt dimensions

A flat belt with dimensions of 411.48 cm length, 80.01 cm width and 0.203 cm thickness was tatted between drive and driven shaft (equation 2):

$$\mathrm{L} = 2 \times 197.5 + 1.57 \times 15 + \frac{2}{4 \times 197.5} = 405\ cm$$

Fenders

Two side fenders, made from sheet metal (197.5 × 20 cm), were attached to each side of the conveyor table to prevent the conveyed crop from falling to the sides (Fig. 4).

Supporting pipe

Supporting pipe consisted of two telescoping pipes. The inner pipe diameter was 3.4 cm and length 67.5 cm while the outer pipe diameter was 4.1 cm and length about 117 cm. The pipes were connected to the conveyor belt table through pin joints.

Operational performance

The man-hours per fed was determined using the following formula:

Man-hours/fed = (L × t) / A……... (4)

Where:

L = number of labours.

t = spent time (hours).

A = the area of collected crop (fed).

Time required during the feeding threshing operation was recorded using a stopwatch.

Crop losses

The total crop losses percentage (TCL) was calculated before and after developing the thresher using the following equation (Mishram and Desta 1990):

$$Tcl\ \% = (T_{fe} / T_{cr}) \times 100 \ldots\ldots..(5)$$

Where:

Tcl= total crop weight losses percentage (kg)

T_{cr}= total crop weight before feeding (kg)

T_{fe} = total crop weight after feeding (kg)

Machine developing cost

Cost of the developed system divided into:

1- Cost of linking the developed feeding device to thresher (iron angles, iron flanges, iron sheet, other tools).

2- Cost of power transmission parts (Table 4).

Results and discussion

Labour requirement and costing evaluation

The labour requirement was only 2 man-hr/fed for the developed thresher as compared to 6 man-hr/fed with the undeveloped machine, which was a labour saving of 43 %. The cost of harvest was 32 DSG/fed as compared to 75 SDG/fed with undeveloped machine (Figs. 5 and 6). However, statistical analysis showed significant differences between the two threshing operation methods in terms of labour requirement and harvesting cost.

Time of feeding

The obtained results indicated highly significant difference ($P< 0.01$) between the two threshing operation methods. As shown in Figure (6), conventional threshing operation resulted in higher man hrs/fed (0.08 hr) compared to the developed thresher (0.03 hr). However, the improved developed thresher with conveyor feeding resulted in highly significant savings of 2 man-hrs/fed compared to the undeveloped thresher with direct manual feeding. Therefore, the use of conveyor feeding belt reduced the required threshing time. El-Awad (2007) found that, such designed conveyor-feeding belt could be used in the thresher feeding of grains, so as to improve the threshing operation performance.

Crops losses measurement

Figure (7) illustrated that at a feeding rate of 10 kg/min, the maximum values of total crop losses percentage (10 %) was obtained when using direct manual feeding threshing, compared to the developed conveyor feeding threshing machine with 6 % crop losses. On the other hand, increasing feeding rate from 2.5 to 10 kg/min increased the total crops losses by 20 % and 30 % for the developed and undeveloped threshing machine, respectively.

Statistically the difference between the two threshers was highly significant. Results indicated that the developed machine decreased the percentage of grains losses compared to the undeveloped machine due to the uniform distribution of wheat plants along the developed feeding conveyor, which enable plants to enter the threshing chamber from the wheat spikes direction, thus uniform impact is resulting in low percentage of grains losses. Results also showed that, the unstrapped legumes loss increased by increasing feeding may be attributed to the increase in the thickness (bulking) of crops. However, these results are in agreement with Badawi (2002).

Conclusion

A feed conveyor thresher was successfully developed and evaluated for its performance. The overall performance of the developed feeding, conveyor thresher was satisfactory for threshing of faba bean and wheat crops. The development of mechanical threshers has clearly proved to be necessary in order to reduce the drudgery of threshing works to a great extent.

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Table 1: Technical specification of stationery thresher "ElSHAMS"

Technology specification	ElSHAMS
Length (mm)	4020
Width (mm)	2200
Height (mm)	24000

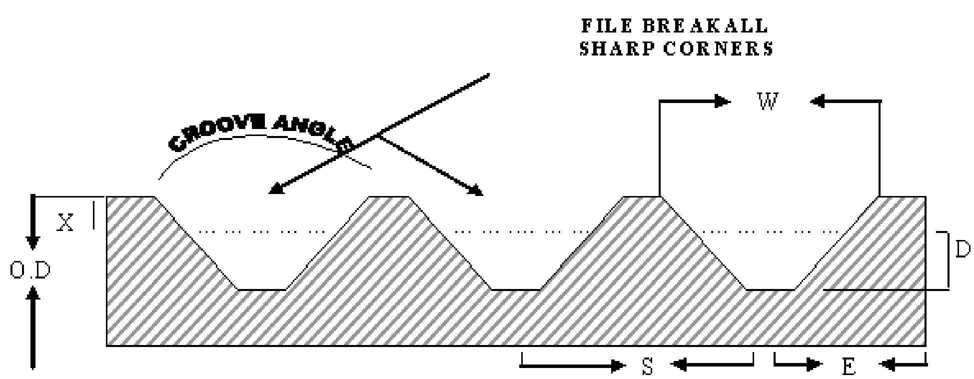
Table 2: Standard V-belts sections

Belt section	Width a (in)	Thickness b (in)	Hp range one or more belts	Minimum sheave diameter (in)
A	½	11/32	¼ - 10	3.0
B	21/32	7/16	1 –25	5.4
C	7/8	17/32	15 –100	9.0
D	11/4	¾	50 –250	13.0
E	11/12	1	100 and up	21.6

Source: Shigley and Mitchell, 1983

Table 3: Groove dimensions and tolerances for multiple V- belt Sheaves

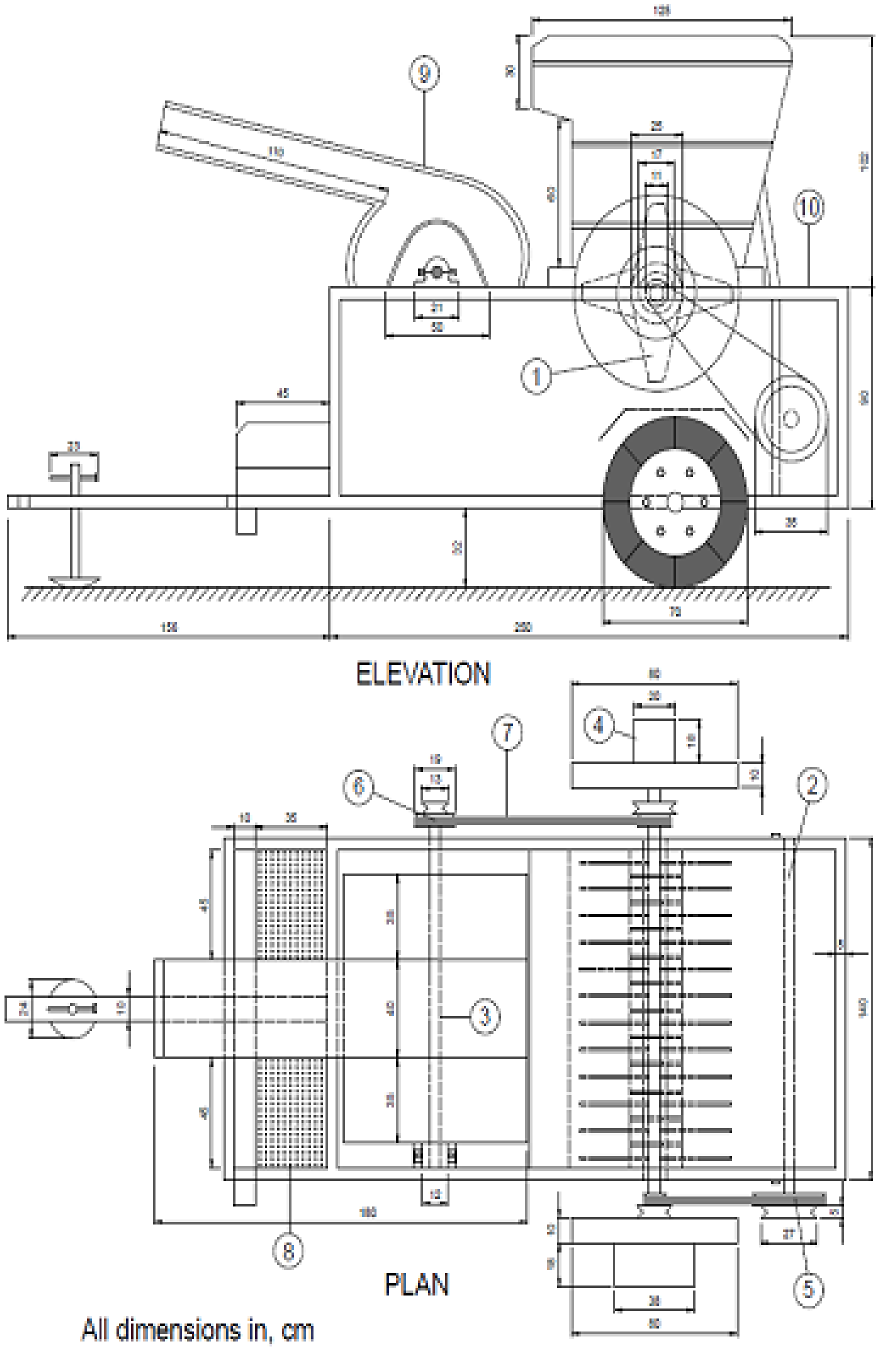
Belt	Pitch diameter		Groove angle	Standard groove Dimension (inch)					Deep groove Dimension (inch)				
	Minimum recommended	Range		W	D	X	S'	E	W	D	X	S'	E
B	3.0	2.6 to 5.4 Over 5.4	±1/2°	(2)	±.031	…	±.031	(3)	(2)	±.031	…	±.031	(3)
			34° 38°	.494 .504	.490	.125	5/8	3/8	.589 .611	.645	.28	3/4	7/16



Source: Machinery's Handbook (2000)

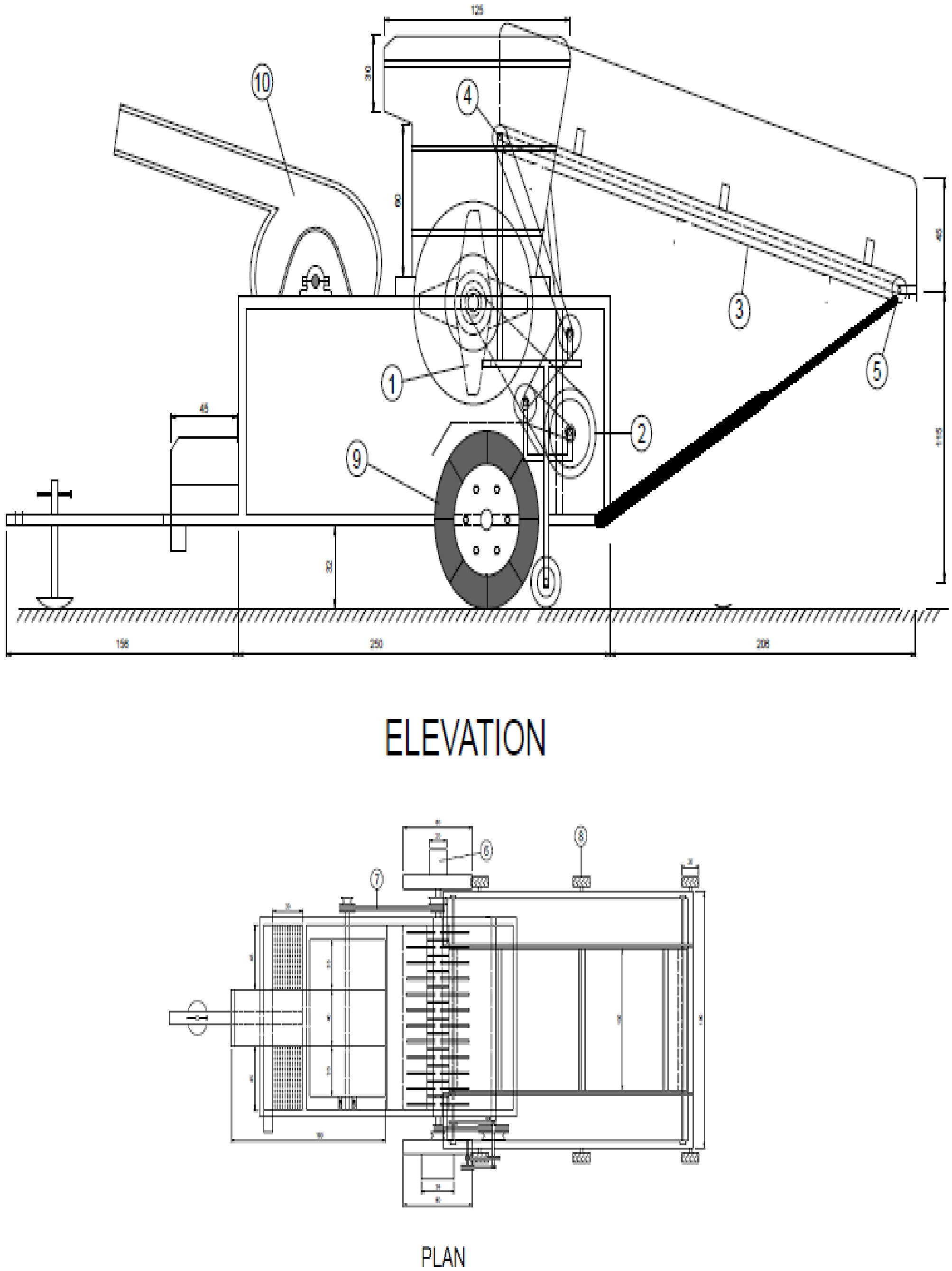
Table 4: Cost of developed parts

Items	Price in SDG
Fasteners, shim, angles etc.	250
Workshop and labour	500
Supporting pipe	100
Pulleys and rollers	0200
Conveyer belt and V-belt	0100
Total	1150



No.	Part name	No. off	No.	Part name	No. off
1	Threshing drum	1	6	Fan pulley	1
2	Sieve shaft	1	7	V-Belt	2
3	Fan shaft	1	8	Sieve	1
4	Guide pulley	1	9	Blower	1
5	Sieve pulley	1	10	Frame	1

Figure 1: Elevation and plan of stationery thresher before development



All dimensios in, cm

No.	Part name	No.off	No.	Part name	No.off
1	Threshing drum	1	6	Guide pulley	1
2	Sieve pulley	1	7	V-Belt	5
3	Flat belt	1	8	Device wheel	6
4	Edler pulley	1	9	Thresher wheel	2
5	Edle pulley	1	10	Blower	1

Figure 2: Elevation and plan of stationery thresher after development

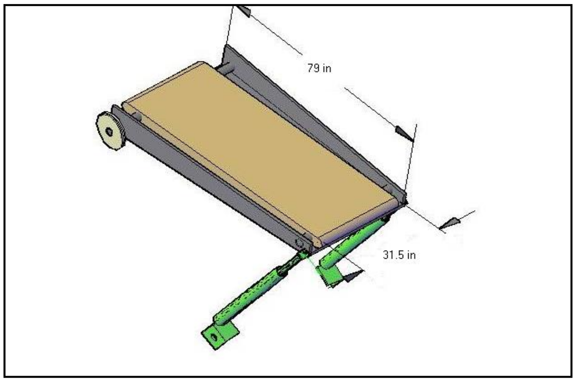


Figure 3: The frame for feeding conveyor

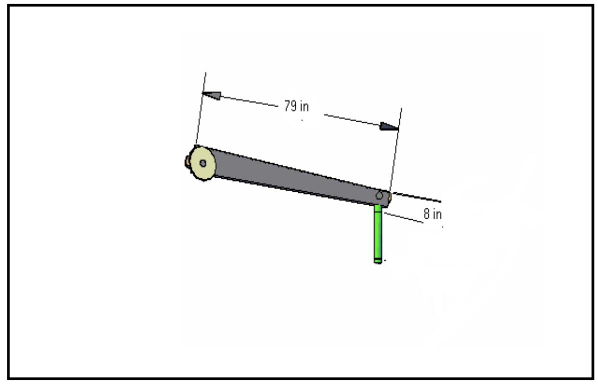


Figure 4: The Fenders

Plate 1: The developed feeding device

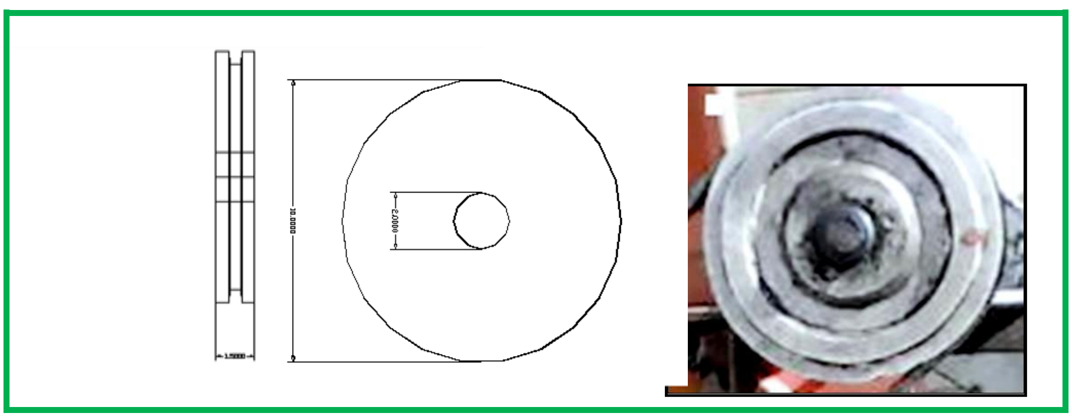


Figure 5: pulley for conveyor belt

Plate 2: Shaft and pillow-block ball bearings

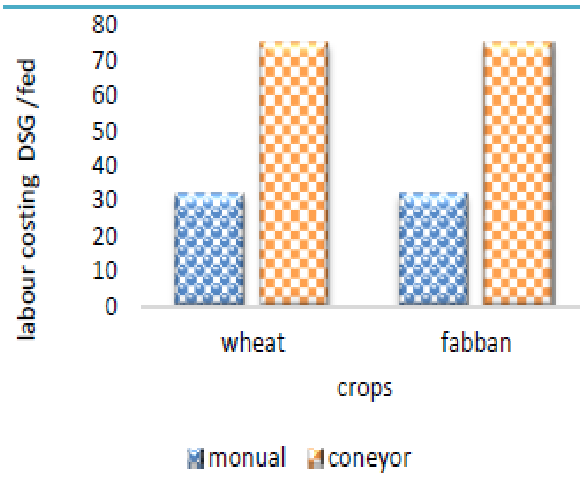


Figure 6: average of Labor requirement

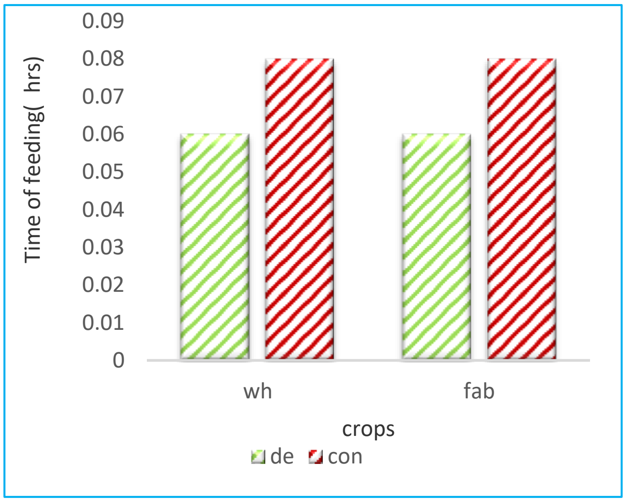


Figure 7: average of feeding time

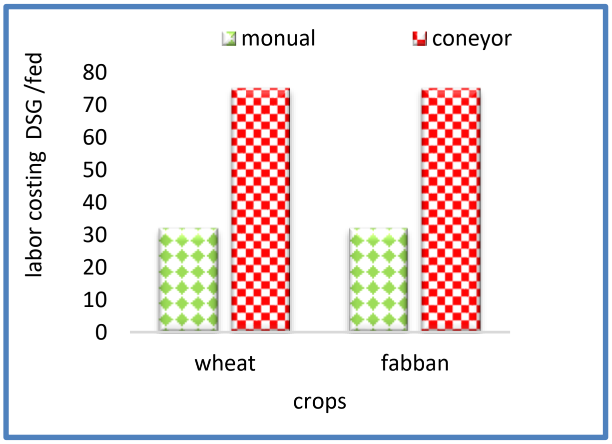


Figure 6: average of Labor costing

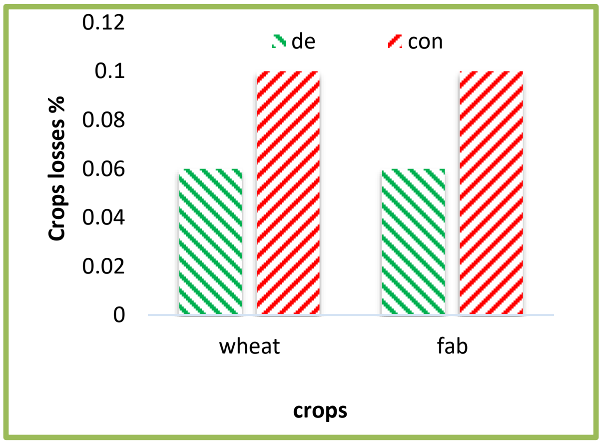


Figure 8: average of Crops losses