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Field Performance Evaluation of a Power Reaper for Rice Harvesting

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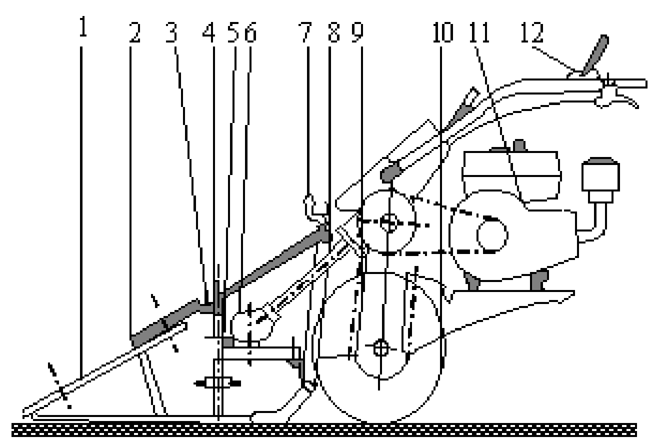
Abstract: 4GL-120A power reaper was described to save time constraints and reduce the cost of harvesting operation of rice by mechanization. This reaper was studied to recommend the appropriate system for rice harvesting. The system was evaluated according to the technical parameters: knife speed, operating speed, actual field capacity, and theoretical field capacity, field efficiency, cutting efficiency, cost economics and percentage of grain losses. The actual cutting width of the reaper was 1.2 m. In this study, performance of power reaper used for rice harvesting was assessed and compared with manual harvesting using sickle. The results showed that the actual field capacity of the reaper was 0.24 ha/h compared to 0.05 ha/h for manual harvesting. Labor requirements for reaper and manual harvesting were 4 and 28 man-h/ha, respectively. The fuel consumption, knife speed, field efficiency and cutting efficiency were 1.89 l/h, 1.223 m/s, 92% and 98% respectively. The cutting cost of power reaper was 67% less as compared with manual harvesting. The grain loss was less than 0.5% and was admissible. The overall performance of power reaper for rice harvesting was found satisfactory.

Keywords: Efficiency, Evaluation, Field Performance, Rice Mechanization.

I. INTRODUCTION

As Myanmar is primarily an agricultural country, agriculture and farm production play an important role. Rice is one of the major crops being produced in the world. Harvesting of crops is an important field operation. Harvesting is the process of collecting the mature rice crop from the field. Harvesting operation includes cutting, laying, gathering, transporting, stacking the cut crop. Harvesting methods being used are manual harvesting and mechanical harvesting. The most farmers use manual harvesting with sickles which consumed more time and labour and then more cost requirements. To overcome these problems, mechanical harvesting is required to minimize grain losses and quality deterioration and to maximize grain yield, field capacity and efficiency and also save total cost requirements. The use of a large scale machine is inappropriate because it needs high technical experience for operation and maintenance and the large investment necessary. And then, field efficiency is low in small holdings and losses of straw are high on irregularly furrowed soils.

So, the use of mechanical reaper is appropriate for small holdings, the large investment unnecessary and low technical operation and maintenance experience. Reaper is a rice harvesting machine which reaps crops mechanically and lays down the stems, providing an alternative to using laborers to gather in crops by hand at harvest time. In this study, power reaper 4GL-120A is mainly described. This reaper has five dividers. Only the left one separates the crop to be cut from the uncut crop. Rice sticks coming from four guide paths are cut by the cutter bar. After cutting, the star wheel passes the crop to the conveyor chain which



(1) Drive rubber belt (2) Big belt pulley (3) Upper carrier chain (4) Lower carrier chain (5) Driving carrier chain (6) Reaping gear box (7) Elevating mechanism (8) Universal drive shaft (9) Main gear box (10) Tyre (11) Diesel engine (12) Controls

Fig.1. Structural diagram of power reaper.

transfers the cut crop to the right outlet. Reapers are featured by simple structure, small volume and easy operation and maintenance and can be used for wheat/rice harvest. The benefits of reaper are more work which is done by short time and reaped with few people. It can be transported from one field to another due to its light weight where most of local farmers have no farm road. Not only men but also women can operate comfortably. The structural diagram of 4GL-120A power reaper is shown in Fig.1 and top view of this reaper is shown in Fig. 2.

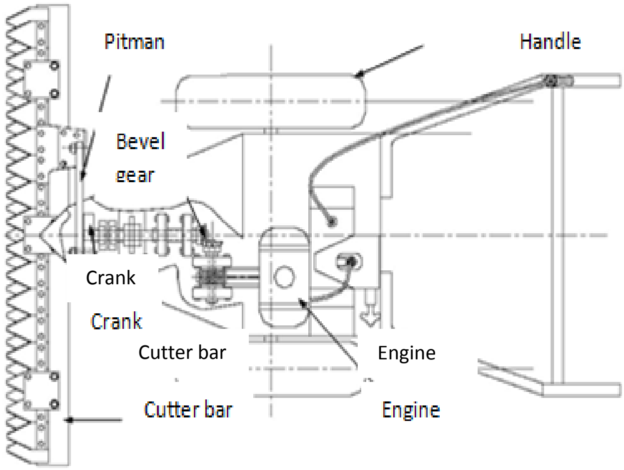


Figure 2. Top view of power reaper.

Also, detailed technical specification of the 4GL-120A power reaper is shown in Table I.

TABLE I: TECHNICAL SPECIFICATION OF A POWER REAPER

SI No.	Parameters	Specifications
1	Manufacturer	China Jinwa Group Nanjing Dajinshan Industrial Co.,Ltd and Myanmar
2	Model	4GL-120A Power Reaper
3	Dimension L × W × H (mm)	1990 × 1490 × 985
4	Weight(kg)	220
5	Power unit	5 HP single cylinder 4-stroke,air cooled diesel engine
6	Working capacity(ha/h)	0.2 to 0.4
7	Crop release	Right side of the machine(Viewed from rear)
8	Operation mode	Self-propelled walking type
9	Applicable crops	Rice and wheat
10	Total loss	<0.5%
11	Applicability	Dry and wet field
12	Cutting device	Reciprocating cutter bar
13	Cutting height(mm)	45 from ground level(adjustable)
14	Cutting width(mm)	1200
15	Travelling Device	Dough nut tyre wheel

II. FIELD PERFORMANCE TEST

This is carried out to obtain actual data on machine performance, operating accuracy, work quality and adaptability to varied crops and field conditions.

A. Preparation of Operation Field

In order to minimize the loss in reaping, before operation, it is necessary to prepare the field.

- Manually cropping on the four sides of field with width of 20cm to prevent the loss due to the fact that machine can't reach the sides in reaping.
- Manually cropping on four corners of field with square of 2×2 m, so that machine can smoothly turn in field as shown in Fig. 3.

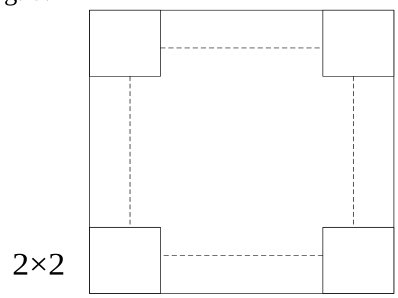


Fig. 3.Preparation of operation field.

- The power reaper is applicable to the rice and wheat. The wheat straw and rice stalk that have length within range of 50~120cm and with the lodge angle of 10° above are fitted to operation of power reaper as shown in Fig. 4.

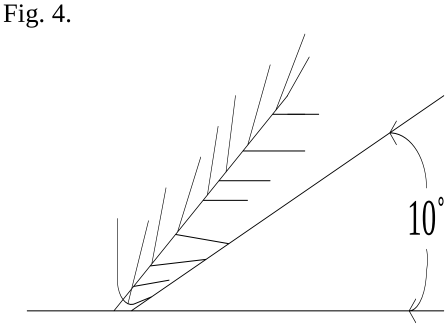


Fig.4. Preparation of power reaper depends on lodging angle.

B. Operation Method

When coming across with protruded part of field land where power reaper cannot operate, as field condition is different, it is necessary to field edge reaping method, which is adaptable to conditions.

- Reaping method of left turn is the field standard operation method as shown in Fig. 5.

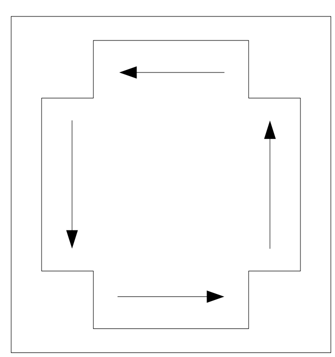


Fig. 5.Left turn reaping method.

- Reciprocating reaping method is suited to right angled quadrilateral long and narrow field as shown in Fig. 6.

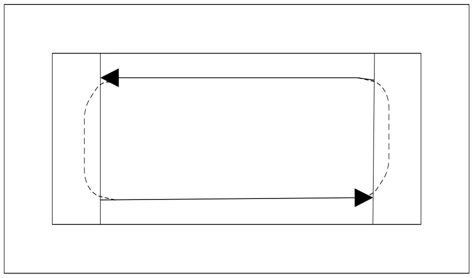


Fig.6.Reciprocating reaping method.

- In big field, reciprocating reaping parted from the center will enhance the productivity as shown in Fig. 7.

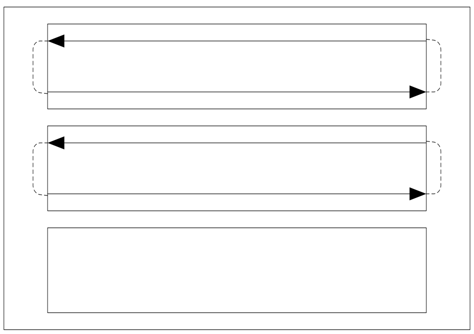


Fig. 7.Parted reciprocating reaping method.

- In the field with irregular condition, first reap the short beveled side as shown in Fig. 8.

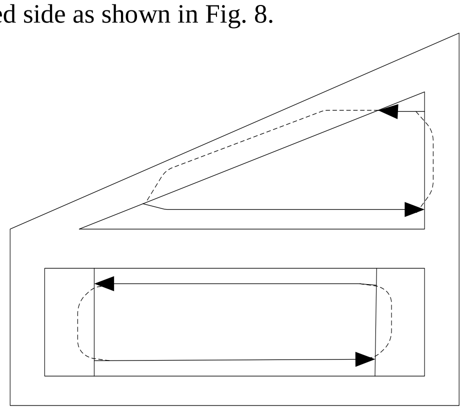


Fig. 8. Reaping method in irregular field.

- When the lodging is serious, lateral reaping in one direction should be used.

C. Changing of Direction of Reaper

When changing the direction of power reaper in small sized field, driving backward and turning round reaping method can be used, and gear shifting and through "driving forward" ,"reversing". Changing the direction using "driving forward" method is a good method. The turning round reaping method needs no gear shifting, but field edge area is larger than that of using the "reversing". In the wet field, the turning round reaping method is more effective; however, the field edge is wider as shown in Fig. 9. According to the characteristics of tyre, it rises when moving forward and sinks when reversing, so using the turning round reaping method is more suitable.

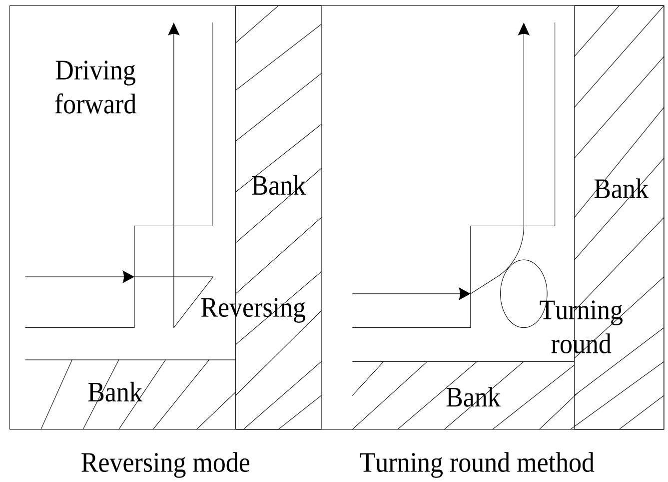


Fig.9. Changing direction of reaper.

D. Changing the Handle Height of Reaper

For various height of person, the height of handle can be adjusted by changing the position of holes on the handle as shown in Fig. 10.

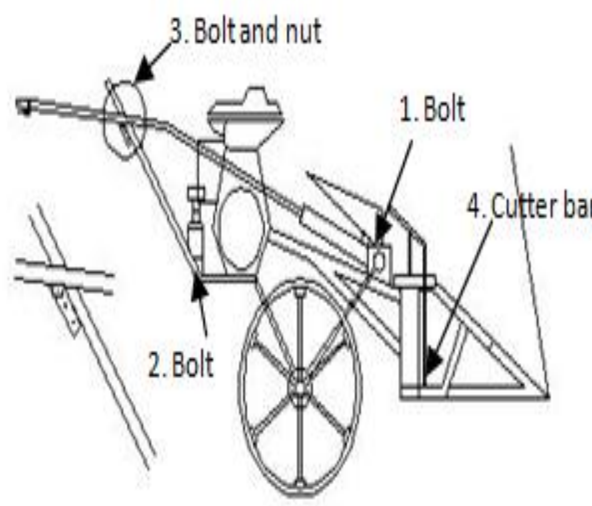


Fig.10. Changing handle height of reaper.

E. Changing of Reaped Height

The reaped height requiresto change for various height of rice as shown in Fig. 11.

- Reaped height in dry fields ranges from 10 cm to 30 cm.
- Most suitable length of ears of rice ranges from 50 cm to 100 cm. In case ears of rice are too short in length, the sidelong feeding of them may be impracticable. And in case they are too long in length, sidelong feeding and releasing of them may fall into disorder, and as the result of it, grains of rice may fall.

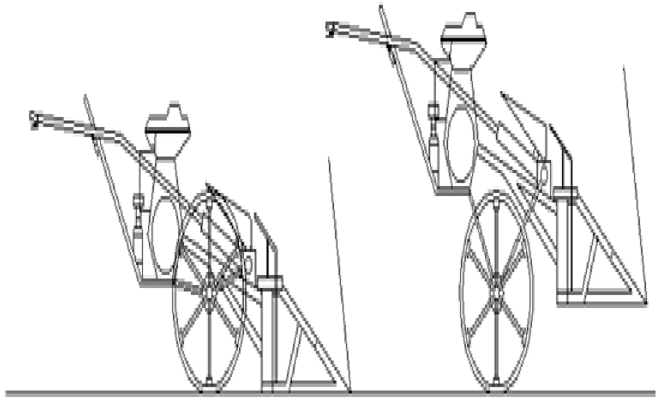


Fig.11. Changing of reaped height.

- Reaped height can be easily changed by the handle up and down motion. Because of wheel shaft bearings are joined with frame.

F. Reaping Near Footpaths

When reaping near the footpaths, it must be careful to prevent the raped crop from clogging the carrying portion of getting caught in the carrying chain.

- When the footpath is low, slightly raise the cutting height so that reaped crop is delivered over the footpath as shown in Fig. 12.

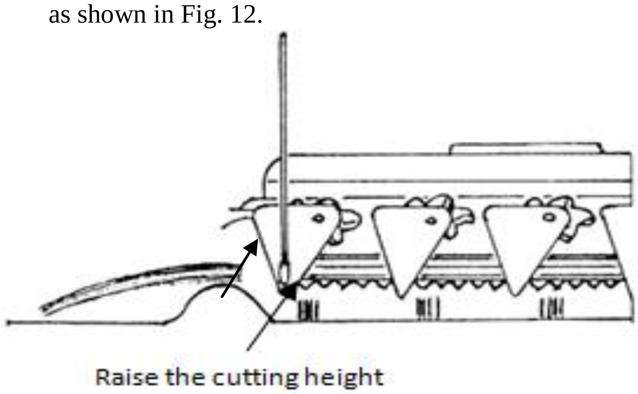


Fig.12. Reaping with low footpath.

- When the footpath is high or weedy, but higher cutting height is not desired, reap by hand the few rows near the footpath as shown in Fig. 13.

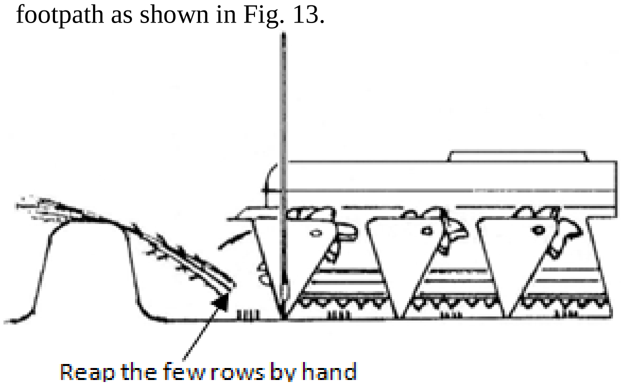


Fig.13. Reaping with high footpath.

III. EVALUATION OF FIELD PERFORMANCE OF A POWER REAPER

The performance of power reaper was evaluated in the rice field. Cutting mechanism consists of fixed lower knife and reciprocating upper knife wherein its movement is controlled by the crank connected to the gear box or belt drive. The stroke length and the width of the standard type knife are 50 mm.

A. Knife Speed

Using the following equation, the knife speed was calculated.

$$V_k = \frac{Sn}{30} \qquad \textbf{(1)}$$

Where:

V_k	= knife speed, m/s
S	= length of stroke, m
n	= crank speed, rpm

B. Operating Speed

On the outside of the long boundary of the test plot in field operation, two poles 20 m apart (A, B) are placed approximately in the middle of the test run as shown in Fig. 14.

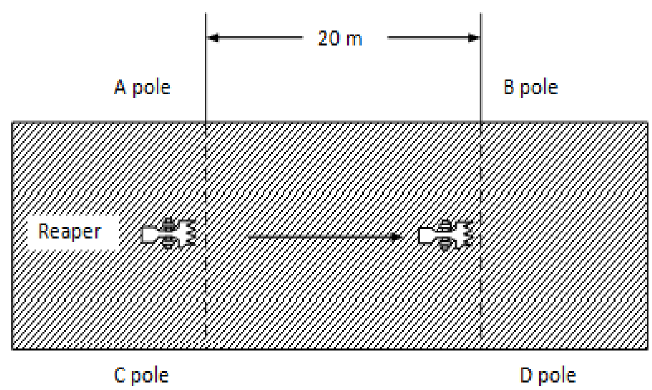


Fig. 14. Measurement of operating speed.

On the opposite side also, two poles are placed in similar position, 20 m apart (C, D) so that all four poles form corners of a rectangle, parallel to at least one long side of the test plot. The speed will be calculated from the time required for the machine to travel the distance (20m) between the assumed line connecting two poles on opposite sides (A, C) and (B, D). The easily visible point of the machine should be selected for measuring the time. The operating speed was calculated using the following equation.

$$S_0 = \frac{3.6D}{T} \qquad \textbf{(2)}$$

Where:

S_0	= operating speed, km/h
D	= harvesting distance, m
T	= harvesting time, s

Speed ratio was the average reciprocating knife speed over operating speed.

B. Fuel Consumption

Fuel consumption, in litres per hour (L/h), is the amount of refueling for the test. In this method, before the start of each test trial, the fuel tank shall be filled to its capacity and after each test trial; the tank shall be refilled using graduated cylinder. When filling up the tank, keep the tank horizontal so as not to leave empty space in the tank.

$$F_c = \frac{q}{t} \quad \textbf{(3)}$$

Where:

F_c = Fuel consumption, l/h
q = quantity of fuel consumed, li
t = consumption time, hr

C. Actual Field Capacity

Actual field capacity, actual rate of being able to reap crop, was calculated based on area covered, and actual time. The actual time pertains to the total operating time which includes the time spent for turning at the headland, adjustment of machine and machine trouble.

$$FC_A = \frac{A_T}{T_0} \quad \textbf{(4)}$$

Where:

FC_A = actual field capacity, ha/h
A_T = area covered during test, ha
T_o = total operating time, h

D. Theoretical Field Capacity

Theoretical field capacity, computed rate of being able to reap crop, was calculated based on the operating speed and the width of the equipment.

$$FC_T = \frac{W_c \times S_0}{10} \quad \textbf{(5)}$$

Where:

FC_T = Theoretical field capacity, ha/h
W_c = Cutting width, m
S_0 = Operating speed, km/h

E. Field Efficiency

Field efficiency is the ratio of the actual field capacity and theoretical field capacity, expressed in percent.

$$E = \frac{FC_A}{FC_T} \times 100 \quad \textbf{(6)}$$

Where:

E = Field Efficiency, %
FC_A = Actual field capacity, ha/h
FC_T = Theoretical field capacity, ha/h

F. Cutting Efficiency

Cutting efficiency was calculated based on the number of rice plants in 20m length was counted before operation and the plants left in same 20m length were counted after operation.

$$CE = \frac{W_1 - W_2}{W_1} \times 100 \quad \textbf{(7)}$$

Where:

CE = Cutting Efficiency, %
W_1 = Number of plants before cutting
W_2 = Number of plants left after cutting

G. Cost Economics

The cost of mechanical harvesting can be calculated on basis of fuel required for the operation, labor charges, etc and was compared with the manual operations.

$$Less\ Cost = \frac{C_m - C_r}{C_m} \times 100 \quad \textbf{(8)}$$

Where:

C_m = Harvesting cost by manual, K/day
C_r = Harvesting cost by reaper, K/day

H. Percentage of Grain Losses

Percentage of grain losses was obtained by the following equation.

$$P_{gl} = \frac{G_y - W_g}{G_y} \times 100 \quad \textbf{(9)}$$

Where,

P_{gl} = Percentage of grain losses, %
W_g = Weight of output grain, kg/ha
G_y = Weight grain yield, kg/ha

IV. RESULTS

Rice was harvested using 4GL-120A power reaper. Performance data were collected to assess knife speed, operating speed, field capacity, field efficiency, cutting efficiency, losses due to machine operation, fuel consumption and labor requirement. Rice is harvested when 20% grain moisture. The moisture content of grain at the time of harvesting found 20% to 25% (wb).The knife speed, field efficiency and cutting efficiency were found to be 1.223 m/s, 92% and 98% respectively. As crank speed increased, the knife speed also increased. According to rice density, rice was cut at different operating speeds for checking reaper motion resistance, running conditions and harvesting quality. The operating speed was higher in low rice density and lower in high density. The reaper shall be operated at the speed of 2 km/h to 5 km/h. At operating speeds greater than 5 km/h, blockage was noticed on the cutter bar unit due to the high density of the rice and insufficient engine power. To prevent blockage, harvesting was performed at operating speeds less than 5 km/h. The theoretical field capacity increased and the fuel consumption decreased as operating speed increased. The fuel consumption decreased as predicted at high operating speeds due to the constant engine speed during harvesting. In addition, at high operating speeds, the field efficiency decreased because the total time lost did not increase proportionally to the increase in the harvesting time.

The cutting efficiency decreased as number of plants left after cutting increased. The cutting efficiency also varied due to low speed of blade provided more torque at the edge of blade so stems cut easily but at high speed, low torque it was difficult to cut the stems. The cutting cost of power reaper was 67% less than with manual harvesting. Percentage of grain losses using reaper was 0.4%. The field losses depended on variety, maturity, and field condition, speed of machine and time of harvest. The performance characteristics of the power reaper were shown in Table II.

TABLE II: COMPARATIVE PERFORMANCE CHARACTERISTICS OF POWER REAPER WITH MANUAL HARVESTING IN TRANSPLANTED PADDY

SI No.	Parameters	Harvesting Methods	
		Mechanical	Manual
1	Power source	5 HP diesel engine	Man power
2	Rice variety	Manawthukha	Manawthukha
3	Date of nursery raised	22-11-2013	22-11-2013
4	Date of transplanting	7-1-2014	7-1-2014
5	Date of harvesting	7-5-2014	7-5-2014
6	Study area(ha)	0.24	0.24
7	Speed of operation(km/h)	2.18	NA
8	Width of operation(cm)	120	NA
9	Time required(h/ha)	4 h 10 min	20 h
10	Actual field capacity(ha/h)	0.24	0.05
11	Theoretical field capacity(ha/h)	0.262	0.051
12	Field efficiency (%)	92	98
13	Cutting efficiency (%)	98	97
14	Labor requirement /day (including collecting and building)	4	12
15	Fuel consumption(L/h)	1.89	NA
16	Cost of operation(K/day)	10000	30000

NA = Not Applicable

V. CONCLUSIONS

The overall performance of reaper was quite satisfactory. The average cutting efficiency and actual field capacity was found 98% and 0.24ha/h respectively. Time taken to harvest 0.6 acre or 0.24 hectare of rice area was about 1 hour and the fuel consumption of reaper was 1.89 l/h. The price of reaper was K 990,000. The local supplier of the reaper only sells the machine and has no spare parts. The maximum area on which the reaper operated in a year is 288 acres or 120 hectares. The cost of manual harvesting was K 30000/day as against K10000/day in the case of mechanical harvesting. If the machine is used for 60 hectares or 30 days, the cost of mechanical harvesting would be K 300,000 (without fuel cost and maintenance) as compared to K 900,000 in the case of manual harvesting. Thus it is feasible to reduce the cost of harvesting operation of rice be mechanization to almost one-third the cost of manual harvesting.The farmers are convinced that the cutting of crop by reaper is much faster than manual cutting by sickle. So, power reaper is more suitable for farmers and other customers. It is also suitable for mountain and hilly areas. The operation was smooth, without noise and any exhaustion to the operator. Therefore, the farmer or labor in agricultural field is very comfortable for reaping with machine.

VI. ACKNOWLEDGMENT

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VII. REFERENCES

[1] Operation Manual of 4GL-120A Power Reaper, China Jinwa Group Nanjing Dajinshan Industrial Co.,Ltd.

[2] Philippine Agricultural Engineering Standard Paes 213: 2004, Agricultural Machinery – Rice Reaper – Methods of Test.

[3] Victoria Robert, "Study on the Performance and Economics of Binder and Reaper at Different Cutting Heights", Department of Agriculture Sabah, Malaysia.

[4] M.V.Manjunatha, B.G.Masthana Reddy,S. D. Shashidhar And V. R. Joshi, "Field Performance Evaluation of Vertical Conveyor Paddy Reaper", Department of Agricultural Engineering, University of Agricultural Sciences, India.

[5] A. Celik, "Design and Operating Characteristics of a Push Type Cutter Bar Mower", Ataturk University, Faculty of Agriculture, Department of Agricultural Machinery, 25240 Erzurum, Turkey.

[6] Atul R. Dange, "Development and Performance Evaluation of Tractor Front Mounted Pigeon Pea Stem Cutter", Central Research Institute for Dryland Agriculture, Hyderabad-500059 (A.P.), India.

[7] Mohammad Reza Alizadeh, Iraj Bagheri And Mir Hussein Payman, "Evaluation of a Rice Reaper Used for Rapeseed Harvesting", Rice Research Institute of Iran.

[8] K.G. Kumar And M.Chowde Gowda, "Power Tiller Front Mounted Reaper for Finger Millet Harvesting", Division of Agricltural Engineering, University of Agricultural Sciences,Bangalore-560 065.

[9] T.Guruswamy, S.R. Desai, M. Veeranagouda And R.D. Barker, "Performance Evaluation of Vertical Conveyor Reaper Windrower", College of Agricultural Engineering, Raichur.

[10] B.C.Parida, "Evaluation, Constraints and Acceptability of Different Types of Vertical Conveyer Reaper for Harvesting Rice in Coastal Orissa, India", Agricultural Engineering Division, Central Rice Research Insitute, Cuttack, Orissa, India.