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Performance evaluation of high capacity multi crop thresher on 'gram' crop

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■ **Abstract :** The present study was undertaken on high capacity multicrop thresher for threshing gram crop at three different speeds of 550 rpm, 600 rpm and 650 rpm at corresponding feed rate of 16q/h, 18q/h, 20q/h. Performance of the experimental thresher was evaluated with respect to threshing efficiency, cleaning efficiency, grain loss, grain breakage and the output capacity. In threshing gram, the maximum threshing efficiency was found to be 98.98 per cent at cylinder speed of 600 rpm and feed rate 20q/h. Similarly cleaning efficiency was found 97.30 per cent at cylinder speed of 600 rpm and feed rate 20q/h while the maximum total grain loss was found 3.3 per cent at cylinder speed 550 rpm and maximum feed rate 20q/h. The grain breakage was found 1.70 per cent at cylinder speed of 650 rpm and feed rate 20q/h. The output capacity was found 9.62q/h at cylinder speed of 600 rpm and feed rate 20 q/h. The net saving with multicrop thresher in threshing cost compared to traditional threshing method was found to be 31per cent for gram crop.

■ **KEY WORDS :** Concave clearance, Feed rate, Tachometer, Threshing efficiency, Depreciation, Straw-grain ratio

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Threshing is the process of loosening or removing separating grain from the ear heads. It consists of sequence of operations that are designed to detach the desired product from the mass of the harvested crop material and to separate it from the mixed mass. The earliest known method of threshing is to beat the grain out from the ears of gram with a stick. Threshing by man power is a time-consuming and labour intensive process. It is done by rubbing between the hands or beating by sticks or striking the plant against a hard object. The Egyptians and Indians (in Vedic time) used to separate out loosened sheaves on wide area of firm ground and then used to separate out grain by driving oxen to trample over the spread heap of harvested material. The Romans used their 'tribalism' (a heavy wooden platform mounted upon rollers) for threshing. It was dragged by oxen. The old method of threshing such as flailing, trampling and rolling are still practiced in many parts of India and other developing countries of the world. In this process not only threshing cost is high but the time required and losses of grain are also high due to natural and biological factors Harrington (1970). Conducted tests with a multi crop thresher and concluded that the un threshed grain were below one per cent for the entire wheat, paddy, mustard and maize crop. On threshing kalyan sona wheat variety at 7.5 per cent moisture content and a cylinder speed of 1200 m/min there was 1.1 per cent un threshed and 1.4 per cent broken grain. Saeed *et al*. (1975) reported that the cleaning efficiency increased with increased speed at constant feed rate from 98.3 to 99.7 per cent and threshing efficiency increased with speed of threshing drum at constant feed rate from 98.51 per cent to 99.45 per cent and decreased with increase in feed rate at constant speed.

The multi-crop threshers which are used to handle number of crops are highly successful for threshing cereal crops and pulses. The advantage of multicrop threshers is that with minor adjustments it can be used to thresh different crops, whereas other threshers can thresh a particular crop only. In efficient threshing not only requires substantial time but also cause considerable threshing losses of grain. An improved mechanical thresher would improve timelines of operation and also reduce threshing related losses. Mazumadar (1985) conducted an experiment on multi-crop thresher that was operated by 5hp electric motor and reported that the output of the capacities of thresher at maximum feed rate were 348,276, 200, 540, 635 and 392 kg/h for wheat, soyabean, sorghum and paddy crop respectively. The threshing efficiency were approximately 99 per cent in most cases, cleaning efficiencies were 99, 97, 99 per cent for wheat, sorghum and slightly lower for other crop, respectively Desta (1988) designed and development a power operated thresher for sorghum crop. He concluded that the threshing efficiency increased with the increase in cylinder speed for all feed rates and cylinder concave clearances. The threshing efficiency was found in the range of 98.3 to 99.9 per cent. Cleaning efficiency and sieve loss were observed to increase with feed rate and cylinder concave clearance.

The multi-crop threshers operated by 10 to 20 bhp stationary engine, electric motor or tractors are becoming increasingly popular. The thresher consists of sieves and frame. Threshing is achieved by giving impact to the crop form a rotating drum (threshing cylinder) which causes grains to separate from the ear head. The separation and cleaning of grain from the chaff is achieved with the help of air flow (blower) and oscillating sieves. The crop is threshed by the impact and rubbing action between the drum and concave. The threshed bhusha and grain falls on the oscillating sieve and being lighter is sucked by the blower and thrown out. The oscillating action of the sieve along with stream of air separates and cleans the grain. The thresher can thresh different crop like wheat, gram, barely, mustard and pea etc. by little adjustment and replacement of sieves.

A high capacity multicrop thresher (Amar thresher) designed by CIAE, Bhopal and manufactured by Bharat Industrial Corporation, Moga, Punjab has been extensively tested in the present work. The thresher was powered by the by 35 to 75 hp tractor or 20hp electric motor.

■ METHODOLOGY

To study the performance of high capacity multicrop thresher, for threshing gram the variables under study where classified as follows:

Independent variable :

Cylinder speed :

Three different speed were selected for determining the thresher performance on gram crop. The selected cylinder speed for gram was 550 rpm (18.31m/s), 600 rpm (21.98m/s), 650 rpm (23.81m/s).The thresher was operated for 15 minutes at no load and with the help of tachometer the speed of the threshing drum was noted after the thresher attained constant speed.

Feed rate :

The amount of crop materials fed inside the threshing unit will affects the overall performance in terms of threshing efficiency and grain damage percentage. Three feed rates were selected for crop gram. The feed rate for gram was selected as 16q/h, 18q/h and 20q/h, respectively.

Dependent variable :

The following dependent variables were measured during the experiments.

Threshing efficiency, cleaning efficiency, total grain loss, grain breakage and output capacity.

Experiment setup :

The experiments were carried out at farmer’s field in villages Narbari of Allahabad district in year 2009. The multicrop thresher was placed on level ground for stability. The thresher was run by a 35 hp tractor. The power was transmitted to threshing drum by the PTO shaft of tractor. The pulley of the blower shaft and the shaking unit received power from the cylinder shaft with the help of v- belt drive and flat belt, respectively. Different level of speed was obtained by fitting different sizes of threshing drum pulley. The concave clearance adjustment was done by raising or lowering the pegs, and fixing it to the holes provided the purpose. The grain straws were collected from different outlet by using trampling sheets. A wooden platform was placed near the feeding through for easy feeding of the crop.

Experiment procedure :

While testing, the thresher was installed on a level ground. A tarpaulin was spread around the thresher. Gram crop were selected for this study at farmer field in village Naribari of Allahabad district. The PTO shafts were properly aligned with cylinder pulley. The pulley for desired cylinder speed was selected and mounted on the cylinder shaft. The thresher was run at no load for a few minutes for functional checking and cleaning of threshing cylinder and sieves and then actual threshing of sample was carried out.

In conducting tests for threshing gram, the cylinder speed was kept at 550 rpm, 600 rpm, 650 rpm corresponding to 18.31m/s,21.98m/s and 23.81m/s linear speed. The upper shaker sieve with 12.75 mm size holes and lower sieves with 9.75 mm size hole were selected. The upper shaker sieve with 6.75 mm hole size and lower size hole with 3.75 mm sieve were used. Desired sieve were fixed to the shaker frame by means of the nut and bolts. During operation cylinder speed was measured using hand tachometer. The test was conducted in village Naribari under the Shanker Gher block of Allahabad district in year 2009.

Measurement of variables :

Threshing efficiency :

It is the ratio of threshed grain received from all outlets with respect to total grain input expressed as percentage by weight.

For determination of threshing efficiency samples from the straw outlet chaff outlet, main grain outlet and sieve underflow were collected at equal intervals for each experiment at the outlets.

Main grain outlets	-	30 seconds
Straw outlet	-	10 seconds
Chaff outlet	-	20 seconds
Sieve over flow	-	30 seconds

The total quantities of materials obtained at these outlets were processed for eliminating unwanted materials from the grain. The grain from the straw was separated manually and the grain with chaff collected at chaff outlets was winnowed manually and weighed separately. The grains from all outlets were weighed for determining the threshing efficiency using the following equation.

Threshing efficiency = 100 - % unthreshed grain

Percentage of unthreshed grain :

It is the ratio of total quantity of un threshed grains from all outlets to the total grain input per unit time and expressed in percentage.

Percentage of un threshed grain = (D/A) x 100

where,

A=Total grain input = B+C+D

B=Quantity of clean grain from all outlets per unit time.

C=Quantity of broken grain from all outlets per unit time.

D=Quantity of unthreshed grain from all outlets per unit time.

Blown out grain percentage :

It is the ratio of the quantity of the grain blown out to the quantity of the total grain input by weight. In order to find the blown out grain percentage, partially broken straw coming out of the thresher at chaff outlet was collected and the threshed grain was separated manually using a hand operated winnower and weighed. The percentage of blown out grain was calculated from the following equation.

Blown out grain, % = (G/A) x 100

where,

G= Quantity of clean grain obtained at bhusha outlet per unit time.

Grain damage percentage :

It is the ratio of the damaged grain to the total grain in the sample. In order to find out the percentage of grain damage, a 100 gram sample was taken from the main grain outlet and grains that have visible cracks were sorted out and weighed. The percentage of broken grain was calculated from following equation.

Grain damage, %= (C/A) x 100

Cleaning efficiency :

It is defined as the ratio of the weight of clean grain and the grain containg straw expressed in the percentage.

For the determination of cleaning efficiency a representative sample of 100 g was taken from the main grain outlets and grains were separated from the sample and weighed. It was calculated as below:

Cleaning efficiency, %= (M/F) x 100

where,

M=Quantity of clean and broken grain obtained from grain outlet per unit time.

F= Total quantity of sample obtained from main grain outlet per unit time.

Spilled grain percentage :

It is the ratio of the weight of the clean grain obtained at sieve over flow to the total grain input per unit time and expressed in the percentage.

Spilled grain,% (K/A) x 100

where,

K=Quantity of clean grain obtained at sieve underflow.

Measurement of dependent variables :

Threshing efficiency, cleaning efficiency, total grain loss, grain breakage, output capacity.

Threshing efficiency :

Threshed grain received from all outlet with respect to total grain input expressed as percentage by weight.

Cleaning efficiency :

Clean grain received at the main grain outlet with respect to total grain mixture received at main outlet expressed as percentage by weight.

Percentage of total grain loss :

It is weight of damaged grain and unthreshed grain collected at all outlets expect main grain outlet.

Percentage of grain breakage :

It is observe that breakage loss was inversely proportional to the moisture content and directly proportional to the drum speed (Mohan 1971). Mass of broken grains from main grain outlet with respect to total clean grain received at main grain outlet expressed as percentage by mass.

Output capacity :

Total quantity of threshed grain received at the main grain outlet for test duration and expressed as kg/h.

Physical properties of gram crop :

The physical properties of gram crop such as moisture content and straw grain ratio were determined as follows;

Moisture content of grain :

Three samples of grain were taken and moisture content was determined by over drying method. A 50 g of sample was placed in the oven at 100 C for twenty-four hour and weight of dry sample was taken. The sample was then placed in desiccator to cool down and weighed. The moisture content was calculated as follows:

$$\text{Moisture content, percentage (db)} = \frac{W_1 - W_2}{W_1} \times 100$$

where,

W_1= Initial weight of the sample

W_2= Final weight of the sample after drying W_1

Straw-grain ratio :

Straw grain ratio was determined by selecting five samples of gram and mustard crops weighing ½ kg each were taken to determine straw grain ratio. Grain were separated from each sample manually and weight of grain and straw were measured separately by using physical balance.

After that it was determined as given below:

Straw grain ratio = W_1/W_2

where,

W_1= Weight of straw separated from crop.

W_2= Weight of grain separated from crop.

Cost operation :

Cost operation is very important factor to judge the performance of any machine over its counterpart machines and methods performing the same operation. Thus, in order to compare the economics of the multi crop thresher over manual threshing, the cost of operation was calculated.

The following assumptions were made for calculating the operation of the thresher.

–Initial cost of thresher = Rs. 57000

–Life of thresher = 10 years

–Number of useful working hour = 300 hr/year

–Rate of interest = 12 per cent per annum.

Procedure for calculating the cost of operation :

Fixed cost :

Depreciation :

It is the loss in the value of the capital item due to change in model, wear and tear, breakdown etc., straight –line method was used to calculate the depreciation as given below:

Depreciation = (P-S)\LXH Rs./h

where,

P = Initial cost of the machine, Rs.

S = Salvage value (Rs.) = 0.1P

L = Life (year)

H = Number of useful working hours (h/hr)

Interest :

Interest on the investment on a farm is a legitimate cost, since the money spent in buying a machine cannot be used for other productive purpose. The rate of interest (I) was taken as 12 per cent/annum as prevalent in the market.

Interest was calculated as shown below:

$$Z \frac{(P\,H\,S)}{2} x \frac{i}{100} x \frac{1}{h}, Rs./h$$

where,

I = the rate of interest (%)

Taxes, insurance and shelter :

Taxes, insurance and shelter were taken as 1.5 per cent, 0.25 per cent and 0.55 of purchase cost, respectively (Hunt, 2001).

Total fixed cost = Depreciation + Interest + taxes + Insurance + Shelter

Variable cost :

Fuel cost :

Cost of fuel is taken as Rs.34.50 as prevalent in the market. Lubrication cost, repair and maintenance charges taken as 5 per cent of purchase cost (Hunt, 2001).

Labour charges :

The labour considering the working of hours as 8 hrs per day the labours were @ Rs. 80 by farmers.

Labour charges= Rs.80 per day

Total variable cost/h

= fuel cost + Lubrication cost + Repair and maintenance + Labour charges.

Total cost of operation (Rs./h)

= Total fixed cost + total variable cost.

Statistical analysis :

In analysis of variance two way classifications was be applied for drawing conclusion for experimental data. The calculated value was compares with tabulated value at 5 per cent level of probability for appropriate degree of freedom.

RESULTS AND DISCUSSION

This chapter deals with evaluation result of testing of high capacity multicrop thresher (Amar thresher) on gram and mustard crop in the field test. The result obtained were analysed and discussed under the following heads.

Crop condition:

Physical properties of gram crop :

Physical properties of gram crop should determine by proper methods.

Performance evaluation :

The effect of performance parameter has been discussed under the following heads.

Threshing efficiency, cleaning efficiency, total grain loss, grain breakage, out put capacity.

Threshing efficiency

The test result of feed rate and cylinder speed on threshing efficiency for gram has been given in the Table 1 and shown in Fig 1. It is evident from the figure that the maximum threshing efficiency 98.98 per cent was obtained at the 20.0 q/h of feed rate and 600-rpm cylinder speed. While the minimum threshing efficiency of 91.23 per cent was obtained at the feed rate of 16q/h and cylinder speed of 550 rpm as the feed rate increased

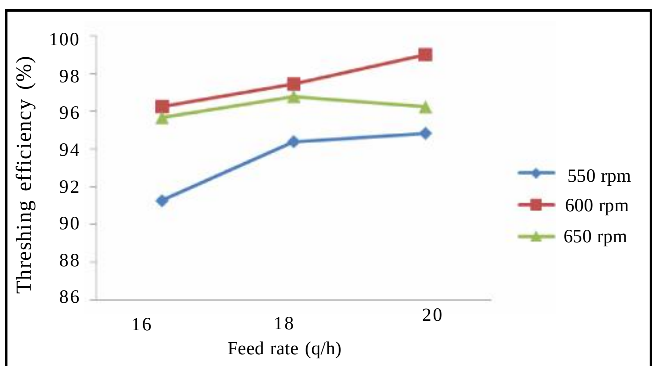

Fig.1 : Effect of cylinder speed and feed rate on theshing efficiency of gram crop

from 16 to 20q/h, the threshing efficiency increased from 91.23 per cent to 94.80 per cent at 550 rpm cylinder speed. Similarly for the same range of feed rate the threshing efficiency increased from 96.23 per cent to 98.98 per cent and 95.63 per cent to 96.76 per cent at cylinder speed of 600 rpm to and 650 rpm, respectively.

Above result revealed that for all set of observations minimum and maximum threshing efficiency were obtained at the feed rate of the 16 to 20 q/h, respectively. The threshing efficiency increased with increase in speed of cylinder from 550 to 600 rpm. However, in general with the increased in feed rate, the threshing efficiency increased except at cylinder speed of 650 rpm where it declined at 20 q/h feed rate.

The increased in threshing efficiency due to increase in speed may be attributed to higher energy imparted by the threshing drum resulting in better threshing of the crop material in the threshing unit. However, on further increasing the threshing drum speed to 650 rpm, reduction in threshing efficiency was noticed.This could be due to the reasons that at very high cylinder speed parts of the material carried away by the rotating threshing drum thus efficiency improper threshing of the crop mass. At high threshing speed excessive grain breakage was also observed. These results are in conformity with the finding of Vas and Harison (1969).

From Fig. 1 it is evident that the threshing efficiency was increased with increase in feed rate at all cylinder speed. This was the cause high energy, therefore, high compaction shearing force on the crop materials in the threshing at the higher speed. The threshing efficiency decreased at the cylinder speed from 600 to 650rpm.

Cleaning efficiency :

The relationship between feed rate, cylinder speed and cleaning efficiency is presented in the Table 1 and shown in Fig. 2. The maximum cleaning efficiency of 97.30 per cent was obtained at 20q/h. feed rate and 600 rpm of cylinder whereas a minimum cleaning efficiency of 94.23 per cent was obtained at 16q/h. feed rate and 550 rpm of the cylinder speed. As the feed rate increased from 16 to 20q/h the cleaning efficiency increased from 94.23 per cent to 95.43 per cent. Similarly for the same range of feed rate the cleaning efficiency increased from 95.26 per cent to 97.30 per cent and 95.36 per cent to 96.46 per cent at cylinder speed of 600 rpm and 650 rpm, respectively.

Above results revealed that for all set of observations minimum and maximum cleaning efficiency were obtained at the feed rate of 16 and 20q/h, respectively. The cleaning efficiency increased with increasing in speed of the cylinder from 550 to 600 rpm. However, at 650 rpm cylinder speed cleaning efficiency

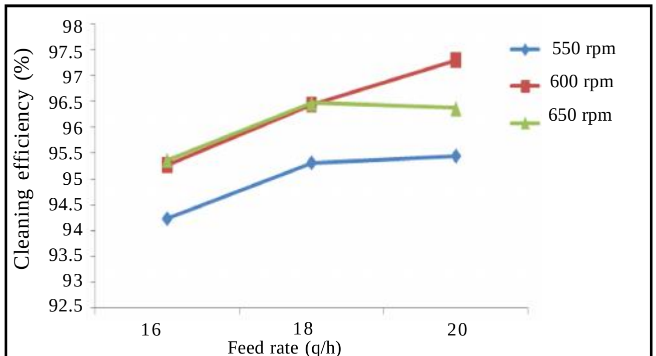

Fig. 2 : Effect of cylinder speed and feed rate on cleaning efficiency of gram crop

Table 1 : Effect of the drum speed and feed rate on performance of high capacity multicrop thresher (Amar thresher) on gram crop (Moisture content=18%)

Cylinder speed rpm	Feed rate q/h	Threshing efficiency %	Cleaning efficiency %	Total grain loss %	Grain breakage %	Out put capacity (q/h)
550	16.0	91.23	94.23	2.5	0.75	7.48
	18.0	94.36	95.30	2.8	0.82	8.54
	20.0	94.80	95.43	3.3	0.86	9.23
600	16.0	96.23	95.26	1.8	0.78	8.73
	18.0	97.43	96.43	1.4	0.88	8.90
	20.0	98.98	97.30	2.4	0.90	9.62
650	16.0	95.63	95.36	1.5	0.86	7.92
	18.0	96.76	96.46	1.9	0.98	8.94
	20.0	96.20	96.36	2.1	1.70	9.20

decreased beyond 18 q/h feed rate.

As evident from the Fig. 2 that with increased in cylinder speed, the cleaning efficiency increased. Since the speed of blower and oscillations of sieve and grain pan increased with cylinder speed, the cleaning efficiency was also affected considerably. The increase of the cylinder speed causes increase of blower speed, resulting high air blast, thereby increased the cleaning efficiency.

Total grain loss :

The test result of the cylinder speed and total grain loss in gram crop is shown in Table 1 and Fig 3. From the figure it is the clear that the minimum grain loss was found to be 1.4 per cent at cylinder speed of 600 rpm at feed rate of 18 q/h while the highest grain loss 3.3 per cent was found at the speed of 550 rpm and the feed rate20q/h.

It is observed from the Fig. 3 that the grain losses decreased with the cylinder speed and also increased with feed rate. This may be observed due to the rate of high energy transfer from pegs to crop materials in the threshing chamber. This was also due to the more impact and shearing force on the crop material between concave and pegs.

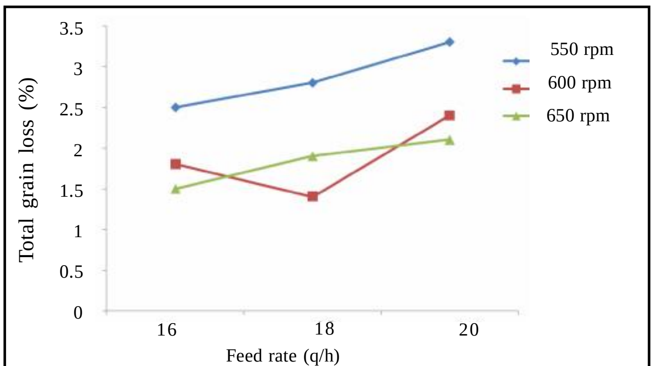

Fig. 3 : Effect of cylinder speed and feed rate on total grain loss of gram crop

Grain breakage :

Table and Fig. 4 showed the relation between cylinder speed and grain breakage in gram crop at the cylinder speed of 550 rpm, 600 rpm and 650 rpm feed rate 16, 18 and 20 q/h, respectively. The maximum breakage observed to be 1.70 per cent at higher cylinder speed 650 rpm and feed rate of 20q/h while there was moderate breakage at medium cylinder speed 600 rpm and minimum breakage of 0.75 per cent were obtained at lower cylinder speed 550 rpm and feed rate 16q/h. More grain breakage at higher speed was due to greater impact by rasp bars of cylinder drum to detach the grain from ear heads, which reflected in the increase of breakage percentage at higher speed.

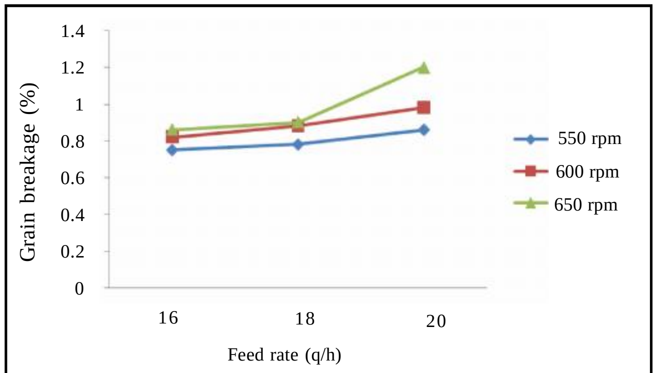

Fig. 4 : Effect of cylinder speed and feed rate on grain breakage of gram crop

Out put capacity :

The Table 1 and Fig. 5 showed the relation between cylinder speed and output capacity in gram crop at cylinder speed of 550 rpm, 600 rpm, and 650 rpm and feed rates 16, 18 and 20q/h, respectively. The maximum output was observed to be 9.62 at medium cylinder speed 600 rpm and feed rate 20q/h and minimum out put capacity was to be 7.48 at minimum cylinder speed 550 rpm and feed rate 16q/h.

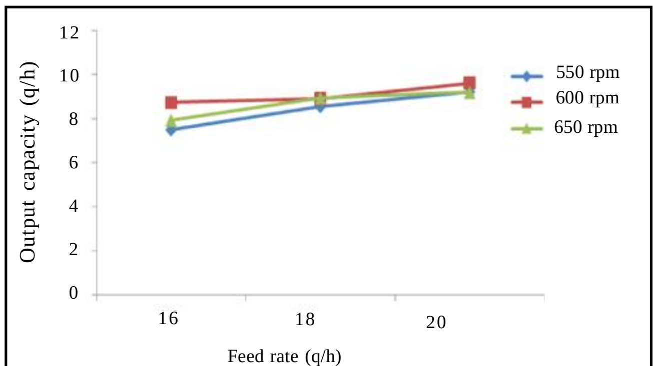

Fig. 5 : Effect of cylinder speed and feed rate on output capacity of gram crop

Cost analysis :

The cost of operation of the high capacity multicrop thresher was found to be Rs. 46.14/- per quintal for threshing of gram crop (Fig.6). For the traditional method of threshing payment to the labour was made for the quantity of clean grain threshed. In Allahabad district, a

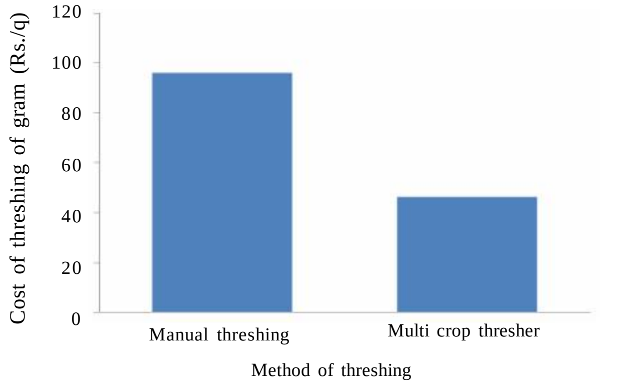

Fig. 6 : Comparison of threshing cost in manual threshing and with multicrop thresher manually

labour gets 3 kg gram for threshing one quintal of clean gram. At present market rate the cost of 3 kg gram is Rs. 96. Thus, there is a net saving of Rs. 49.86 in threshing one quintal of gram crop.

Conclusion :

The testing of multicrop thresher was conducted in village Naribari under Shanker ghar block of Allahabad district for Gram crop. The following are the main conclusions drawn from the study-

The optimum cylinder speed for threshing gram crop was found to be 600 rpm at feed rate 20 q/h. The threshing and cleaning efficiency were 98.98 per cent, 97.30 per cent, respectively and total grain loss 3.3 per cent and grain breakage were 1.70 per cent at above combination of speed and feed rate.

The cost of threshing per quintal of gram crop by multi crop thresher was found to be Rs. 46.14.

The net saving with multi crop thresher in the threshing cost compared to traditional threshing method was found to be 51.93 per cent for gram crop.

Based on these conclusions it may be summarized that multicrop thresher was more efficient, economical and precise than conventional methods used for threshing of gram crop.

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